Title

Growing Environmental Literacy: On small-scale farms, in the urban agroecosystem, and in school garden classrooms

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Growing Environmental Literacy: On small-scale farms, in the urban agroecosystem, and in school garden classrooms

By

Alana B Siegner

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in the

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Committee in charge:
Professor Alastair Iles, Chair
Professor Charisma Acey
Professor Isha Ray

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Abstract

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Food systems in the United States are in need of transformation. The current globalized, mechanized, chemical-based, fossil fuel-powered food system causes negative impacts on ecology, human health, social justice, and local economies. This dissertation explores places where alternatives to the dominant food system are being advanced, and investigates how such alternatives could be scaled up, better supported, or reinforced through food systems education. The crisis of global climate change intersects with the challenge of sustainably (and nutritiously) feeding a growing global population, leading to synergistic opportunities to engage in integrated food systems and climate education. As branches of environmental literacy, which is increasingly promoted in new state standards for K-12 education, food and climate literacy offer opportunities to educate young people while building a climate resilient, equitable local food system. How to build food, climate, and environmental literacy effectively remains a question requiring further action-research. The following chapters address this question through case studies of relocalized food system transitions in Lopez Island, WA and the East Bay region of California's San Francisco Bay Area. Lessons from these two case studies inform a food and climate change curriculum, a work in progress presented in Chapter 4 alongside an overarching analysis of effective, experiential climate change education pedagogy. Ultimately, efforts to reform our food system with the realities of climate change in mind will require young people partnering with allies in older generations to create and scale alternative production, distribution, and consumption practices. Education has a critical role to play in enabling food system transitions and climate solutions, implemented at a community scale but integrated in a global network of climate-friendly food system transformation.

TABLE OF CONTENTS

List of Figures

LIST OF TABLES

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Working on food systems research has led me to build collaborations and community with many students in the Environmental Science, Policy and Management (ESPM) program, including Margiana Peterson-Rockney, who initiated a student-led agriculture and climate change reading group and has hosted numerous "Women in Agriculture" dinners that have socially and nutritiously fueled this research.

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Thanks to all for nurturing this dissertation into being!

CHAPTER 1: INTRODUCTION

This dissertation is inspired by the small farms and farmers that I have had the pleasure of engaging with during my research over the past five years. The food system is widely recognized as being at a critical point, and in need of transformation to address environmental and social justice critiques. The farms and farmers of Lopez Island, Berkeley, Oakland, Alaska, and Vermont I have encountered through my research are on the front lines of working towards environmentally sustainable and socially just food production. They are growing food, educating consumers in their communities, and opening up their farms as spaces of civic engagement. Their work is the manifestation of theoretical frameworks and recommendations from academic literature and forms the foundation upon which to build a better food system for more people. And yet, there remains much complexity and uncertainty around how best to implement climate beneficial and socially just food systems, starting from a production standpoint, requiring farmer-researcher partnerships to investigate and scale emerging best practices.

Volunteering and working on farms have been a crucial observational research method across all of my projects and chapters. Being a participant-observer on diversified, small scale vegetable farms of all sizes and geographies, from Vermont to the San Juan Islands, Oakland to Alaska, has provided me with the evidence I need to understand and interpret scientific articles on climate-friendly food systems. These experiences allow me to connect larger datasets and trends to observable, tangible realities and processes, providing a necessary visual (and visceral) element to illustrate the pages of numbers and text. I could not have completed this dissertation without the love grown from the soil, without hands-on contact with the life forms and biodiversity that give us food, without the conversations with countless passionate urban and rural small scale farmers, doing what they do for the planet and the people rather than profit alone.

1.1 The Food-Climate Nexus

Food system challenges associated with the chemical, industrial production paradigm are increasingly intersecting with the challenges associated with global climate change. The need for change in the dominant food system is widely recognized, prompting scholars to pose questions such as “Can we feed the world without destroying it?” (Holt-Gimenez 2018) and describe competing visions in “the battle for the future of food” (Wise 2019). Despite the often negative “crisis” framing of intersectional food and climate realities, there is an opportunity for proactive framing and empowering outcomes through the alternative paradigm of agroecological food systems. Positive framing, engagement and empowerment are key tenets of effective educational practices for a range of desired outcomes, including environmental, food, and climate literacy. This dissertation draws from both food systems scholarship and climate change education research to investigate synergistic food-climate interactions, focusing on small scale farms and gardens as centers for generating solutions and educating about innovations in food production that are simultaneously adaptive to and mitigating of climate change.

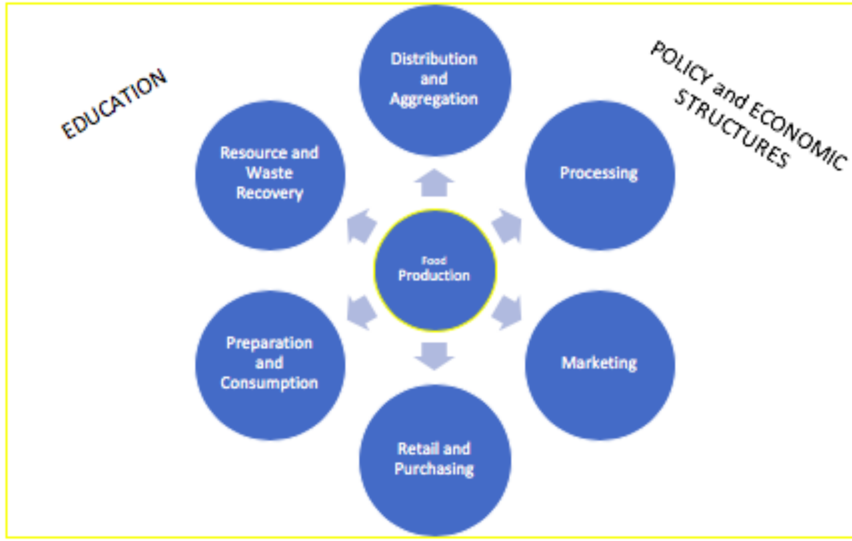

Figure 1- Food System Diagram

Figure 1 shows a diagram of the food system based on commonly-represented elements (production, distribution, processing, marketing, retail, consumption, and waste), but with two modifications: 1) production at the center influencing activities in other spheres, and 2) education and policy/economic structures drawn in the surrounding "box" as important overarching considerations necessary for transitioning to an agroecological food system. This figure guides and frames the research to follow. Centering production, it reflects the data collection process behind this Ph.D. that started with working in the production space on Lopez Island, Washington.

Food systems are both impacting and impacted by the climate system (see Figure 2). The two-directional arrow diagram offers a simplified educational model for teaching about the current impacts of food systems on greenhouse gas emissions, as well as exploring, through experiential learning, practices that reverse traditional impacts and, for example, re-store carbon in the soil. The arrows in Figure 2 are illustrative, and the "impacts" could be positive or negative. For example, currently the food system is adversely impacting the climate system through mechanized production powered by fossil fuels, fertilizer manufacture, soil tillage that releases soil carbon, dietary preferences, and other practices (down arrow). The climate system is also adversely impacting the food system (on the whole) as warming temperatures drive changes in rainfall patterns, exacerbate droughts, disrupt food distribution channels, and create extremes to which current farming practices are not adapted to coping with (up arrow). However, there is potential for the food system to have a more positive set of impacts on the climate system through regenerative agricultural production systems governed by principles of agroecology. The food system has potential to re-store atmospheric carbon and rehabilitate beneficial ecological functions through re-localization and appropriate management, eventually driving more positive climate impacts back to the food system. Temporally, there is a substantial "lag time" in realizing positive climate impacts due to the 100-year residence time of atmospheric CO2;

however, additional motivators for shifting towards an agroecological food system exist in the shorter-term including advancement of social, economic, health, and food justice goals.

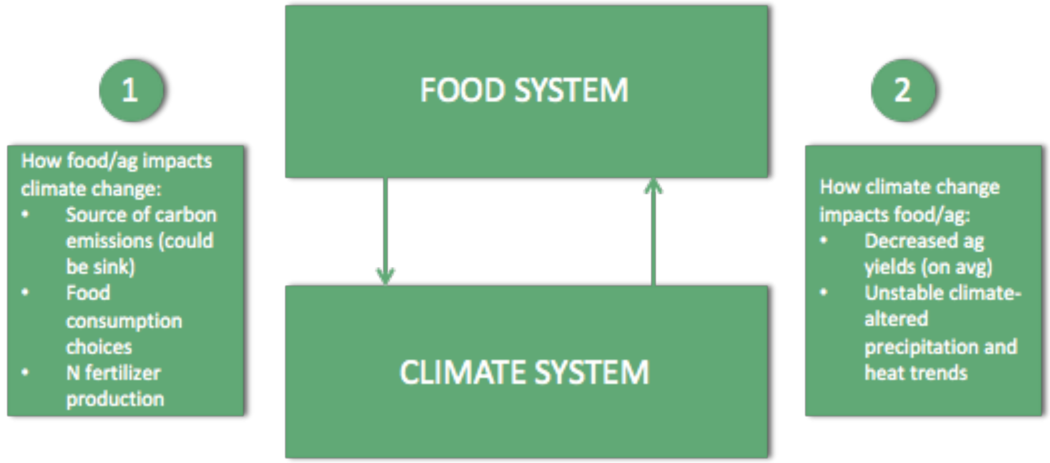

Figure 2- Food Climate Nexus

More complex representations of the food climate nexus exist showing cascading interactions between the food system, climate system, and potential adaptation/mitigation measures. The IPCC Land Use report includes a figure showing complex interlinkages between the climate system, food system, ecosystem (land, water and oceans), and socio-economic system, operating at multiple scales, from global to regional (IPCC 2019, Figure 5.1). Ultimately both complex and more simple diagrams are pointing towards opportunities for food systems actions to reduce and remove atmospheric GHG concentrations. However, doing so without compromising important social justice goals requires coordination and inclusive local food system planning. Debates in the agroecological food system research center around how best to achieve food systems and related social change and are discussed further in section 1.2.1 below.

Emissions inventories quantify the greenhouse gas impact of food systems using various assumptions and "boundaries" between food and other sectors, such as transportation, buildings, and electricity generation. Estimates range from 8-9% of total greenhouse gas emissions attributable to "agriculture" in California and the United States (CARB 2017; EPA 2017), to 33% of total emissions attributable to the "global food system," including fertilizer manufacture, food storage, and packaging (CGIAR cited in Gilbert 2012). As Niles et al. state in a recent paper, "It is estimated that agriculture and associated land use change account for 24% of total global emissions (Smith et al., 2014), while the global food system may contribute up to 35% of global greenhouse gas (GHG) emissions (Foley et al., 2011; Vermeulen et al., 2012). As a result, **food systems**—not just agricultural production—should be a critical focus for GHG mitigation and adaptation strategies" (Niles et al. 2018; emphasis added). And yet, current research on climate change mitigation in the food sector focuses on the production element, without fully exploring other system elements in terms of leverage points, synergies, and tradeoffs in mitigation and adaptation efforts. It is important to consider a holistic accounting of greenhouse gas emissions from the industrial food system, including the manufacturing of nitrogen fertilizers and herbicide/pesticide chemicals; fuel for powering farm equipment; dietary preferences; and processing, packaging, and refrigeration processes, in order to optimize emissions reductions and carbon removal and maximize adaptation co-benefits of mitigating the climate crisis through transforming the food system (Niles et al. 2018).

A recent article written by the International Food Information Council (IFIC) Foundation identifies in a recent survey that only 22% of Americans have heard of "regenerative agriculture:" a way of farming that restores soil biodiversity through activities such as "reduction/elimination of tillage and use of synthetic chemicals; use of cover crops, crop rotations, compost and animal manures; and integrating animals along with perennial and annual plants to create a biologically diverse ecosystem on the farm" (IFIC 2019). This lack of awareness can be attributed in part to lack of public awareness about the true scope of agriculture and food systems impacts on the climate. Both climate and food systems activists are stepping into the void and working to make food a focal point of climate and environmental justice movements, exemplified by Al Gore's Climate Reality Project hosting a Climate and Food Summit in 2019.

As Whendee Silver points out in her food systems chapter of the University of California's recent climate solutions textbook "Bending the Curve,"

> Greenhouse gas **emissions reduction** is a critical component of any plan to slow climate change. However, we have now reached a point where greenhouse gas emissions reduction alone is insufficient to solve the climate change crisis… If we can increase the rate at which **CO2 is removed** from the atmosphere, while at the same time reducing emissions, we have the potential to bend the curve. The Earth's system has built-in ways to remove atmospheric CO2. On land, the most important mechanism to remove CO2 from the atmosphere is photosynthesis by plants. **Plants, and the soils they live in, are tremendous resources in the battle against climate change.** Plants need CO2 to survive and grow, and they have the "machinery" to remove CO2 from the atmosphere. We depend upon plants for food, fiber, fuel, and building materials, so we have perfected plant management—also called photosynthesis management— over thousands of years of practice. Managing plants and soils for carbon uptake and storage *[in addition to food, fiber, fuel, etc]* often translates into more sustainable and productive practices for people and ecosystems. (Silver 2019; italics and bold font added)

There is growing awareness of the power of farming systems to aid in the "battle against climate change" among sustainable farmers, part of a new crop of farmers who are more likely to be college educated than established older farmers (USDA ERS 2019). Farms across the United States are investing in climate friendly practices and on-farm education, including climate change education (CCE). The chapters that follow explore alternatives to the dominant food system paradigm in Washington State and Northern California, valuing and evaluating impacts of alternative food system-building initiatives based on food production and numerous co-benefits such as education, food security, community-building, health/nutrition, ecosystem services, and climate mitigation. Enumerating the values and benefits of agroecological local food systems and small farms has potential to contribute valuable lessons to the broader narrative around changes to the dominant industrial food system that are necessary to avert social and ecological damages. It is increasingly clear that human health and environmental impacts within the food system are interlinked, and "foods associated with improved adult health also have low environmental impacts" (Clark et al. 2019). Therefore, there is great potential for changes in practices on both small- and large-scale farming operations to achieve social, health, and environmental goals synergistically.

1.2 Theoretical Frameworks

This dissertation engages with several important and intersecting theoretical frameworks, including 1) critical food systems and agroecology, 2) social-ecological systems, and 3) environmental literac(ies).

1.2.1 Critical food systems scholars and organizations aligning with the agroecology paradigm point out several dimensions of necessary action-research to build towards a climate friendly food system, including regenerative food production, minimizing corporate influence, preventing further consolidation of corporations, promoting re-localization of food systems activities, and rebuilding a policy climate with accountable elected officials acting in the best interest of society, environment and democracy (Renting 2017; Pimbert 2017; Gliessman 2016). Relocalizing food systems is credited by scholars of agroecology as "an important factor in seeking solutions to the multiple crises" that cities are currently facing, including "environment, climate change, health, social inclusion and waste management" (Renting 2017). Agroecology scholarship spans governance scales and nations, the urban and the rural, and is best understood through the lens of the food system (see Figure 1 above), weaving together production and other system elements (distribution, marketing, consumption, waste recycling).

The agroecological food system paradigm is framed by some scholar-activists as standing in direct contrast to the dominant industrial paradigm and the Law of Exploitation; it is "centered on the Earth and small-scale farmers, and especially women farmers… ecological food systems are local food systems. Sustainability and justice flow naturally from the Law of Return and from the localization of food production. The resources of the Earth… are managed as a 'commons,' or shared spaces for communities" (Shiva 2016). Other scholars such as Elinor Ostrom and David Bollier employ different philosophical and epistemological approaches to suggest management approaches grounded in cooperation and the commons. Ostrom famously posited eight principles for managing a commons, in direct response to Hardin's "Tragedy of the Commons," and she was awarded the Nobel Prize in Economics in 2009 for her efforts. Bollier's book "Think Like a Commoner" frames an alternative political economy, a paradigm of "working, evolving models of self-provisioning and stewardship that combine the economic and the social, the collective and the personal. It is humanistic at its core but also richly political in implication, because to honor the commons can risk unpleasant encounters with the power of the Market/State duopoly" (Bollier 2014). Bollier goes on to use words and phrases such as "bottom-up, do-it-yourself styles of emancipation," "new forms of production," "open and accountable forms of governance," "healthy, appealing ways to live," and "pragmatic yet idealistic" to describe the paradigm of the commons. Inherent in both agroecology and the commons literature is the goal of returning to producers and individuals the power to self-determine systems of production and governance.

Agroecological scholars increasingly engage in articulations of a vision for food system transformation, ranging from a radical overthrow of the status quo to more gradual shifts to current practices (Anderson 2019; Gliessman 2016). Agroecological research is described as "transdisciplinary, participatory, and change-oriented" (Gliessman 2016), and agroecology is commonly defined as a "science, practice and movement" (Wezel et al. 2009). However, there is debate among food system scholars around how change is enacted. Some argue that agroecology is the best way to "feed the world," and in fact, small agroecological farmers are already producing the majority of food consumed by the growing human population on a small percentage of total agricultural lands (Altieri & Nicholls 2012; Wise 2019). Others argue that the land requirements of feeding a growing population through agroecological, regenerative[1], and/or organic farming practices would be so large that land use change would exacerbate rather than ameliorate negative climate impacts associated with food production. These "land sparing vs. land sharing" and "feed the world debates" co-exist with debates around how to enact local food system reforms. I engage primarily with the local food system reform; my findings and contributions do not speak directly to the larger global land use and world hunger debates. Rather than arguing for radical and immediate food system revolution, the three cases presented in this dissertation illuminate opportunities for the current food system to improve along dimensions of sustainability, climate resilience, and education, presenting social and ecological benefits of local food system shifts. The cases advance an argument justifying and valorizing the existence of small farms, more easily able to provide social, ecological, and educational benefits to communities than environmentally destructive industrial farms. These benefits are not guaranteed or inevitable, however, when food systems relocalize or small farms focus on regenerative practices; they require public investment, civic engagement, and participatory action-research to sustain, safeguard, and enable their existence.

1.2.2 Local food systems are inherently complex, social-ecological systems (SES). Food systems researchers bring to the fore "questions such as food...nourishing bodies, soils as living organisms, urban gardens as life-sustaining infrastructure… while taking issues as money, location, skin colour, gender, and social status seriously... Food issues cannot be treated as purely **socio-political**, neither as mere **ecological** or agronomic… They are co-constructions of water, people, investment flows, soil organisms, and more. Agroecology captures this co-construction" (Van Dyck et al. 2017, emphasis added). This excerpt nicely unites the theoretical frames of agroecology and SES, which both endeavor to explain and characterize human-nature interactions. Building a local food system requires an understanding of interdisciplinary topics and collaboration with diverse stakeholders (from ecology to agronomy to economics and political science), implicating systems of education in developing personal as well as institutional capacity for working in interdisciplinary, highly collaborative, environmentally literate teams.

Of particular relevance to the urban agriculture research presented in Chapter 3, recent scholarship uniting SES and urban food system governance highlights a typology of urban agriculture participants with different ways of "governing" urban food production spaces. As Piso et al. 2019 discuss,

> Achieving sustainable urban agriculture depends on policies and regulations as well as social norms and rules, which collectively compose a city's urban governance. As Lemos and Agrawal (2006) point out, governance includes more than the "pure" regulatory activities of state and market actors and must also account for the social practices of community members and organizations…. Urban food production [cultivates] social mechanisms and practices that contribute to that city's resilience (Barthel et al. 2015). These mechanisms include environmental learning and social-ecological memory developed through collective activities like allotment gardening and are vital for wise governance (Colding and Barthel 2013) ... This has led to researchers calling for social-ecological research through which researchers collaborate with stakeholders to better

[1] There are important distinctions drawn in the food systems literature and scholarly community between agroecology and regenerative agriculture; according to some scholars, agroecology more actively "[wrestles] with how it is intertwined with social movements, food sovereignty, and food justice, while RA does not seem to as often or as much...[there has not been] a lot of integration of social justice principles. That seems to leave it more vulnerable to cooptation" by big food corporations (Gurian-Sherman 2019). I use the words more interchangeably to describe production practices in my dissertation as my research partners use both terms fluidly, but want to note the scholarly distinction here.

> understand the values and goals motivating urban agricultural practices (Teschner et al. 2017).

Piso et al.'s typology of urban agriculture distinguishes between those who are, respectively, urban agricultural stewards, risk managers, food desert irrigators, and urban agricultural contextualists. This typology can be applied to urban farms in the East Bay and has implications for how appropriate local policies might be implemented considering the local mix of farmer typologies in the East Bay agroecosystem.

Overall, SES scholarship offers the reminder that "sustainability" of resource management is a collective and shifting concept, meaning different things to different stakeholders in different moments. Therefore, the work that follows presents multiple meanings of achieving sustainability in local food systems: economic sustainability of small farming operations, social sustainability of farming as a lifestyle, and ecological sustainability of the soil resource.

1.2.3 Environmental literacy focuses on capacity building and empowering responsible action of young people and the broader public when it comes to human-nature interactions. It is not a traditional form of "literacy," measured by knowledge and mental aptitude alone. There is a behavioral, affective element. When facing important social-ecological challenges such as those posed by climate change and the industrial food system, environmental education and literacy offer opportunities to confront challenges through grounded knowledge of local environments complemented by awareness of global environmental realities. Knowledge alone does not inherently lead to behavior change (Wolf and Moser 2011), as climate education scholars have repeatedly shown. Pedagogies such as experiential learning are especially well suited to develop knowledge, agency, and engagement with topics in order to increase the likelihood of desired action and behavior changes. Environmental education "is set to become the largest, most effective tool in combating environmental damage and promoting sustainable development. With the planet facing the dire consequences of climate change and a global effort underway to reduce emissions...the question must be asked: How do we include the environment and sustainable development in our education system?" (Ellsmoor 2019). Integrating environmental literacy throughout the education system is a working goal of many researchers, educators, and climate activists.

Food literacy and climate literacy fall under the environmental literacy umbrella: both are more specific forms of environmental knowledge, attitudes and behaviors that deal with human relationships to the natural world, in the arenas of food production/consumption and overall planetary wellbeing. Climate literacy is a complex and evolving topic in the literature, which simultaneously seeks to better measure it and expand the theorization of "literacy" to include informed and effective action to match the scale of the climate crisis. As Drewes and Henderson state in the Introduction to their edited text, *Teaching Climate Change in the United States* (forthcoming, 2020),

> While we collectively celebrate broad attempts to teach people about the principles of climate change science (e.g., United States Global Change Research Program, Climate Literacy: The Essential Principles of Climate Science, 2009), we are most interested in education that will shift social and material conditions in ways that lead to a tangible decline in carbon emissions and toward increased forms of resilience and flourishing for both humans and the more-than-human world. A growing body of research acknowledges the limits of climate science literacy education, as it turns out that it is possible to know a great amount of knowledge about climate change while still acting in ways that

perpetuate the problem (Kahan et al., 2012; Moser and Kleinhückelkotten, 2018). Climate change education must be able to affect change at a scale commensurate with the problem.

Within food literacy research and practice, much work has focused on the sourcing and use of local foods in school cafeterias and classrooms. The National Farm to School Network (NFSN) has grown in the past decade into a major driver for incorporating local and healthy foods into K-12 education. NFSN now includes 42,587 schools representing all 50 states (http://www.farmtoschool.org/). The Farm to School "program model" comprises three elements: school gardens, cafeteria procurement, and **education**, offering curriculum modules for school garden teachers to reference. Other sub-national efforts to define "Food Education Standards" for K-12 schools have more recently emerged from nonprofit organizations such as PilotLight in Chicago, IL and the Center for Ecoliteracy in Berkeley, CA. Despite the importance of the food-climate nexus noted above, few of these food literacy efforts deal explicitly with climate change, missing an opportunity to build forms of environmental literacy synergistically. In the PilotLight Food Education Standards, produced with collaborators from Columbia's Teacher's College and University of Chicago, there are seven simple standards broken down into grade-specific expectations for each standard. The only mention of climate change comes under Standard 3: "Food and the environment are interconnected," in the Grade 9-12 expectation that students "Assess the impact of climate change on food availability" (PilotLight 2019).

There is a gap in food and farm-based K-12 education when it comes to addressing climate change as an integral challenge and impetus for building a better food system. The gap reflects the difficulty felt by many in the K-12 education sector around teaching the topic of climate change with confidence and without controversy. The research of this dissertation fills this gap by developing and evaluating an integrated effort to build food, climate, and overall environmental literacy. Farmer-educator professional development comprises an important component of this overall process.

What strategies and best practices exist for developing multiple forms of environmental literacy synergistically? Can food security and climate education challenges be resolved together? The research presented in the following chapters offers a partial answer to these questions, developing a food systems and climate change curriculum as an example of more creatively integrating environmental challenges into already-successful educational avenues such as school gardens and food-based education. Partnerships with farms, school gardens, food systems researchers, and climate change educators help foster this curriculum into existence and shape it as a work in progress. Food and climate literacy come together in a food production-focused series of activities that guide students towards taking informed action to mitigate climate change through food production and consumption choices. Teaching students how to grow food has an inherent tie to promoting food security and food sovereignty; going one step further, there is an embedded hypothesis underlying this curriculum development that, through participating in where food comes from (how food is grown), students can better understand other aspects of the food system such as the consumption choices and importance of composting rather than throwing away food waste, making the production element an important leverage point for food systems education. Furthermore, food production spaces offer hopeful examples of removing carbon from the atmosphere, acting out the carbon cycle on a local scale. In the words of one school garden teacher, "the garden system is a perfect metaphor for the complexity of the climate system," and thus a promising venue for engaging students in CCE.

1.3 Methodological Foundation

The research studies compiled in this dissertation employ participatory, collaborative, and interdisciplinary research designs. Mixed-method approaches to inquiry combine to yield results, drawing from participant observation, semi-structured interviews, key stakeholder surveys, GIS analysis, and literature review methodologies. The studies draw heavily from interdisciplinary epistemologies that value multiple ways of knowing and seek to incorporate multiple voices, especially those that have been historically marginalized, into the research design, implementation, analysis, and communication of results. The relevant spheres of influence for this grassroots and bottom-up approach to knowledge creation are ultimately decision-makers in climate policymaking and those negotiating food systems power structures.

The research methods are grounded in the study of social science, drawing from texts such as *Constructing Social Research: The Unity and Diversity of Method* (Ragin and Amoroso 2011), *What is a Case? Exploring the Foundations of Social Inquiry* (Ragin and Becker 1992) and *Making Sense of Qualitative Data: Complementary Research Strategies* (Coffey and Atkinson 1996). Michael Burawoy and Pierre Bourdieu inspire the practice of interpreting case studies, embedding them in an appropriate theoretical framework, and understanding interview subjects (Burawoy 1998; Bourdieu 1996). As Walton illustrates in his essay "Making the Theoretical Case," a case can change as you dive into it, and finding the appropriate theoretical frame is the work of the researcher; he cautions against the danger of coming in with a set theoretical frame in mind and trying to force the incoming data into that frame (Walton 1992). Chapter 2 in particular exemplifies a case that started as a case of one thing and became a case of something else as the layers of research methodology, like layers of an onion, peeled back initial assumptions and observations until it struck at the core.

Incorporating Elinor Ostrom's call for better integration of the social and ecological sciences in governing sustainable social-ecological systems (SES) (Ostrom 2009), interdisciplinary research questions in the chapters that follow incorporate natural and social scientists, as well as practical agricultural science. Doing participatory research requires a mix of experience and immersion in the literature to guide those who seek to do social justice oriented, empowering (rather than extractive) work with non-academic research partners. The scholarship of Jill Harrison (Harrison 2011), Jules Pretty (Pretty 1995), Nicole Klenk (Klenk et al. 2017), and Alastair Iles (Iles et al. 2016) is instrumental for guiding researchers towards effective practices that co-produce rather than extract knowledge. These researchers share a focus on climate and food systems research that is especially relevant for this dissertation.

1.4 Chapters that follow

The chapters that follow investigate food systems research questions in the contexts of the San Juan Islands in Washington State, and the East Bay region of the San Francisco Bay Area. While all chapters engage with food systems holistically, each chapter enters into the food systems research question from a different element of the system. The second chapter focuses on the production side, introducing a case study of small-scale sustainable farming at the community scale on Lopez Island. The third chapter presents a food access and distribution research project taking place in the East Bay, investigating pathways through which urban produced foods do (or do not) make it into the hands of food insecure consumers. The fourth chapter uses the lens of education to present an evaluation of a food and climate change curriculum, illustrating how climate change education and food systems research can work together to achieve common goals (climate mitigation and food systems reform). The conclusion synthesizes key findings from all three chapters, pointing out what bigger picture food system questions are answered as well as questions requiring further investigation in the arena of relocalizing climate-friendly food systems. Small farms and farm-based education are ideal prototypes to investigate and disseminate work in this direction.

Key strands of literature running throughout the paper include the literature on agroecology and emerging research on its application to the urban context- urban agroecology (UAE). Chapter 2 engages with the agroecological paradigm for food systems reform in a rural context, and Chapter 3 turns over new questions in the urban East Bay context. The chapter draws on scholarship from a recent RUAF magazine titled "Urban Agroecology," that proposes UAE "not as a goal, yet an entry point into, and part of, much wider discussions of desirable presents and futures… [it is] a stepping stone to collectively think and act upon food system knowledge production, access to healthy and culturally appropriate food, decent living conditions for food producers and the cultivation of living soils and biodiversity, all at once" (Van Dyck et al. 2017). Agroecology and UAE have important implications for how food systems education should be conducted (horizontally, with attention to social justice and equity), which are implicit in the pedagogical foundations underpinning the food and climate curriculum in Chapter 4. The chapters, with their diverse research questions and publication outlets, push back against a food system that destroys human and environmental health alike, and seek out climate friendly alternatives through collaborative, participatory research projects.

The research presented in chapters 2, 3, and 4 make the case for diverse values and benefits associated with relocalizing sustainable and equitable food systems centered around small diversified farms, in places where this type of food system transformation is sought. Rather than arguing for the complete overthrow of the current industrial food system, the primary contribution of these cases is to argue that shifts to current practices are both *necessary* and *possible* yet must be supported by appropriate and enabling governance structures. There are social, ecological, and educational benefits to adopting agroecological food system practices, but it is difficult to enact these practices holistically and systemically across food system elements in the current U.S. political economy. The cases offer lessons or "pilots" that are relevant to the operations of large-scale farms and industrial processes as well as small scale, agroecological operations: through adding plant diversity and minimizing soil disturbance, for example, numerous benefits can be achieved for farmers (economically), for local ecology, and for global climate change. Therefore, findings implicate the policy and planning domain in terms of action needed to sustain and scale positive food system reform impacts, on a variety of levels and with attention to social justice implications. The findings also make important contributions to methods of climate change communication and education: effective CCE will manifest differently in different contexts and must allow for each audience to express the environmental concerns that are most pressing, immediate, and relevant in that context. Through considering food systems and climate systems holistically, opportunities for public health benefits, local environmental improvements, and educational growth can be realized.

Chapter 2: Production: Small-scale Farming and Food Systems Building in the San Juan Islands, WA

2.1 Introduction to Lopez Island Food System

Figure 3- Lopez Island Farmland

Lopez Island is situated 4 miles off the Washington State mainland in the Salish Sea, where it is a lighthouse for an alternative, agroecological model of food production at the community scale. Approximately 18,000 acres of agricultural land in the San Juan Islands chain (~16% of total land area) form a network of non-GMO, non-chemical based agricultural land. The 5,000 acres of Lopez Island farms stand in direct contrast to conventional farming: they are largely small scale, human-powered, diversified, educational, knowledge-intensive, reliant on natural fertilizers and integrated pest management strategies, and localized in terms of who they serve[2]. The Lopez Community Land Trust lists 27 farms on their annually published "farm products guide," on this island of 2,500 year-round inhabitants. Lopez farmers seek to optimize many outcomes besides yield and several actively cultivate seed diversity through seed saving and local exchange. Seeds are selected for drought resilience, flavor, nutrient content, ability to withstand disease and pest pressure, and general endurance and adaptability to local conditions. The resident community is invested in local farms, through school food procurement, local markets, and regular volunteer presence. The summer tourism industry can attribute some fraction of its success to the local food system, as a recent tourism survey indicated "natural/rural scenery" as the top reason and "local food" in the top half of 15 listed reasons tourists come to the San Juan Islands (Whittaker et al. 2018). However, the tourism industry simultaneously poses a challenge to the local agriculture community, as the real estate and land markets are increasingly displacing farmers due to development pressures and desires for second homes on the islands.

As an island community, Lopez has unique considerations around food procurement. Importing food from the mainland (or exporting food) is expensive and risky in the face of natural disasters, as ferry service to the islands is easily disrupted and unreliable in the face of

[2] While some farms on Lopez do employ conventional growing practices that degrade the land resource over time through activities like repeated haying on several hundred acres, this is not the focus or central "ethic" of the Lopez farming community, but rather a sub-set of the farmer population, existing in tension and apart from the community practicing regenerative agriculture. More will be said later on about the potential for regenerative ag to heal the historic divide between "old school" and "new school" farmers, conventional and organic, through emphasizing shared goals around soil health and fertility (see Section 2.4).

adverse weather conditions. Ferry service costs $47 roundtrip from Anacortes to Lopez per vehicle and driver in the summer season. There is an added incentive on Lopez to adopt self-sufficient and soil regenerating farming practices at the community scale due to its geographic isolation in combination with rocky, relatively poor soil quality. This "island incentive" is important to factor in when considering the widespread adoption of sustainable agriculture on Lopez; as the San Juan County Agricultural Strategic Action Plan reports, "islanders naturally place a high value on food security and may benefit from their isolation to preserve genetic diversity, for example, by establishing an organic seed industry" (Bill et al. 2011). As food supply chains in today's globalized food system are increasingly threatened by natural and climate-exacerbated disasters, all communities will soon have (or already have) increased incentives to invest in sustainable food production as a form of resilience, food security, and climate adaptation. In the realm of food self-sufficiency, innovative production systems, and climate resilience, there is much to learn from island nations and communities that are on the front lines of adapting food systems to and mitigating climate change.

Lopez is striving to create a robust, resilient, socially just local food system, a distinct and more complex goal than merely investing in and promoting local food production. Individual farmers starting to adopt and successfully deploy regenerative practices is not the same as creating a sustainable and resilient local food system. A local food *system,* as outlined in the previous chapter, includes not just production, but transportation, distribution, marketing, retail, preparation, consumption, waste recycling, and education across system elements. A food system that is socially just, compensating farmers fairly for their labor while balancing affordability for the consumer across income groups, requires a change in food system economic transactions from the status quo. A food system that is environmentally sustainable and mitigates climate change, storing more carbon in the soil than it releases and minimizing emissions throughout the system elements, requires transformation of the dominant industrial food system. Lopez farmers are striving to increase and quantify their soil carbon reservoir, with less progress to date on reconfiguring the economic status quo.

What can this island farming community tell us about creating and scaling alternatives to the chemical-industrial farming industry? What are the key challenges, tensions, and opportunities on Lopez for building a local food system that is socially just and environmentally sustainable? What are the next steps for Lopez, and other counties or regions, in moving towards goals and vision statements for re-localized food systems? These questions, when answered, become relevant not just to farmers and researchers, but importantly, to policymakers, economists, and businesses that must implement new policies and economic structures effectively in partnership with farmer- and community-generated vision statements.

Significant to the presentation of results and discussion is the supremacy of private property in the United States legal system. When comparing the Lopez agricultural case study to "idealized" visions of agroecological food systems, many steps towards the "ideal" are thwarted by private property "enclosures" of the agricultural commons, which is more pronounced in the United States than in other geographic contexts. The private property system in its current form on Lopez poses a barrier to farmland transitions. Thus, progress towards visioning and establishing agroecological local food systems must reconcile with unique challenges in the U.S. land tenure system, and ultimately promulgate strategies for loosening the supremacy of private property if real power is to be restored to those growing our food.

Through a compilation of fieldwork, ethnographic notes, participant-observation, and immersion into the community, this chapter presents data on the Lopez Island sustainable food system case study, and constructs analysis of food system transformation framed by the paradigm of agroecology (Shiva 2016). I draw on social science research methods including semi-structured interviews and ethnographic techniques to bring forward ideas and solutions from leaders in the agricultural community of the San Juan Islands. Research partners include the San Juan Island Agricultural Resource Committee (ARC), the San Juan Islands Agricultural Guild (Ag Guild), the Lopez Community Land Trust (LCLT), the Lopez Island Farm Education (LIFE) program, Washington State University (WSU) San Juan County (SJC) Extension, San Juan Islands Conservation District (SJICD), Midnight's Farm, Stonecrest Farm, Sweetbriar Farm, and Lopez Harvest. I find that the Lopez food system transformation towards resilience, sustainability, and equity is a work in progress, requiring political and economic shifts in order for regenerative food *production* practices to spark regeneration and equity in other branches of the food system. Significantly, farmland transition barriers and land access challenges[3] combined with new and beginning farmer training are areas requiring further investment, investigation, and institutional capacity in order to secure the progress made to date into subsequence generations of sustainable farmers.

2.2 Literature Review

2.2.1 Agroecology, Climate Change Mitigation, and Sustainable Food Systems

It is already well established in the agroecology and sustainable food systems literature that the chemical-industrial farming system causes adverse human health, labor, social justice, environmental and climate outcomes (Shiva 2016; Altieri 2009; Gliessman 2016; Sandhu et al. 2019). Thus, alternatives to the chemical-industrial farming system are imperative to develop and advance for environmental and social justice reasons. The current dominant food system is driven towards yield-maximizing outputs enabled by increasingly consolidated, mechanized monocultures, which are in turn reliant on a potent mix of chemical fertilizers, pesticides, and fossil fuels. This system functions at the expense of human health, fair labor conditions, equitable food distribution, and environmental preservation. Furthermore, the current food system contributes significantly to the problem of climate change, emitting approximately 25% of the global greenhouse gas emissions portfolio (Silver 2019). Conversely, regenerative agroecological food systems have the potential to store more carbon annually in the soil than what is emitted through processes like respiration and plant decay, which at scale could amount to significant global carbon offsets (on the order of 1 ton C/hectare), buying time for the

Figure 4- Regenerative Agriculture Practices

[3] Farmland access and transition dynamics are issues of national concern not just Lopez-specific, e.g. Calo and Petersen-Rockney 2018

planet to adopt other necessary technological and social changes to reduce carbon emissions (Paustian et al. 2016; DeLonge, Ryals and Silver 2013; Ryals and Silver 2013). Agroecological, sustainable, and organic farmers are leading the way towards demonstrating new ways to both produce sufficient quantities of food and mitigate climate change through soil C sequestration. Regenerative agriculture (RA)[4]'s climate mitigation potential is highlighted in a recently released report from the Rocky Mountain Institute, stating that "negative emissions technologies—natural and engineered strategies for actively removing CO2 from the atmosphere such as agroforestry and silvopasture, biomass gasification and biochar—deployed at scale in the United States could sequester between 0.6 and 1.4 gigatons of C annually by 2050" (Chitkara and McGlynn 2018). A report by Terra Genesis International further breaks down the mitigation potential of regenerative agriculture practices per hectare as depicted in Figure 4.

According to Silver, "plants, and the soils they live in, are tremendous resources in the battle against climate change... soils have the potential to be deep, long-term repositories of some of the carbon captured by plants, keeping it from returning to the atmosphere for years to decades or longer" (Silver 2019). Silver and her team of researchers quantify the impact of existing "agricultural mitigation practices" as potentially lowering global temperatures by 0.26°C by 2100, under RCP 2.6 (Mayer et al. 2018). Other researchers helped develop the "Soil C 4 per Mille" initiative, launched at the COP21 talks in Paris in 2015, calling for all nations to increase soil carbon storage on agricultural lands by 0.004%, which would create a significant global carbon drawdown effect of 2-3 Gt C annually, offsetting 20-35% of anthropogenic emissions (Minasny et al. 2017).

What are these "agricultural mitigation practices" and how exactly can they be scaled across global agricultural acreage? Undoubtedly, local geography and context matter, along with available social, intellectual, and financial resources. This chapter will explore the first half of the question and explore the application of mitigation practice in the San Juan Island geographical context. A selected list of practices most relevant to Lopez Island farms are listed in Table 1 below. It is worth noting that many of these practices, in particular no-till and cover cropping, are broadly relevant to (and beneficial for) agricultural producers in both the conventional and organic industry, offering opportunities to build a "big tent" in the agriculture sector's response to climate change.

Table 1: Agricultural Mitigation Practices

Ag mitigation practice	**Description**	**Sources**
Cover cropping	Ensuring year-round soil cover and photosynthetic activity (CO2 removal) through planting a noncommercial crop, often in late fall, to replenish soil nutrients and reincorporate into soil before spring	Tautges et al. 2019; Poeplau and Don 2015

[4] Importantly, regenerative agriculture (RA) and agroecology are distinct terms with unique political-economic implications. While RA is entering the political mainstream and is being used by "big food" companies seeking to align themselves with climate solutions, agroecologists lament the fact that regenerative production practices are increasingly occurring through channels that seek to fortify rather than revolutionize current political-economic structures, power dynamics, and the global food system "status quo."

	planting	
Compost application	Applying a layer of finished compost to croplands or rangelands annually to provide nutrients and structure to soil, aiding in plant growth as well as carbon and water storage potential; C storage potentially lasting for 30+ years	Tautges et al. 2019; Ryals and Silver 2013; Ryals et al. 2014; Ryals et al. 2015
Biochar	Partially combusted woody material in a low-oxygen environment that becomes a charcoal like substance; Can be incorporated into soils in numerous ways including as a component of compost; has potential to store large amounts of carbon back in soils	Brassard et al. 2016; Nair et al. 2017
Silvopasture and rotational grazing	Grazing animals on native woodlands with some trees present, and grazing animals strategically to allow grassland regrowth	Lal 2004; Nair et al. 2011
Hedgerows and riparian restoration	Planting bushes and shrubs between rows as additional carbon sinks, and paying close attention to conserving or restoring native plantings along rivers, creeks and streams	Falloon et al. 2006
Perennial plantings (trees, orchards, perennial crops)	Farms incorporate plants that grow over the course of many years, rather than strictly annuals. Examples include: fruit trees, berry bushes, forest cover or windbreak, perennial grains)	Crews et al. 2018; de Oliveira et al. 2018
Low/No till systems	Crop production that involves no (or minimal) mechanical tilling or disturbance of the soil prior to planting	Baker et al. 2007; Ogle, Swan and Paustian 2012
Rotational grazing	The practice of moving grazing livestock between pastures on a regular basis in order to rest sections of pasture and establish healthy, nutritious forages.	NRCS; Lal et al. 2015; Bosch et al. 2008

Agroecological research often ties together the climate mitigation impacts of ecological farming with the social justice impacts of farming practices that are regenerative for both land and people, building a framework for conceptualizing and studying the health of interlinked human and natural communities. In the words of Steve Gliessman, “Agroecology is a way of redesigning food systems, from the farm to the table, with a goal of achieving ecological, economic, and social sustainability. Through transdisciplinary, participatory, and change-oriented research and action, agroecology links together science, practice, and movements focused on social change" (Gliessman 2016). Thus social movements focused on poverty reduction, public health, and racial justice are linked in with the agroecology paradigm. This triple bottom line of social, economic and ecological sustainability must be investigated in each context that claims "agroecology" as its mantle.

What is a sustainable food system? Different definitions abound around the term "sustainable agriculture," including Jules Pretty's conceptualization of five forms of renewable capital that contribute to sustainability: natural, social, human, physical, and financial (Pretty 2008). Sustainable is most simply defined as "able to be maintained at the current rate or level in future generations." When the term "sustainable" is applied to "food systems," it extends from food production to distribution, retail, marketing, consumption, and waste management. In the case of Lopez Island farmers, there is repeated emphasis put on the need for farming to be sustainable both in terms of farmland (resources such as soil and water are regenerated so that crops can be grown year after year) AND farmers (the work and compensation are not so demanding or limited that farmers are unable to live a balanced life; new farmers are able to step in and replace retiring farmers). Concerns around farmworker livelihoods, access to health care, work-life balance, farmland transition, and physical wellness are also included in conversations around whether a food system is "sustainable" or "agroecological" (Pretty 2008; Pimbert 2017).

2.2.2 Social-Ecological Systems and Polycentric Governance

Local food systems are complex, social-ecological systems (SES), with humans operating as a part of larger ecological processes and life cycles. As summarized in Biggs et al. (2012), "all social-ecological systems (SES) produce a bundle of ecosystem services (ES), including provisioning (e.g. freshwater, crops, meat), regulating (e.g. flood and climate regulation) and cultural services (e.g. recreation, spiritual values)." Human action (or inaction) affects the resulting ecosystem services, potentially creating imbalances especially as populations rise (e.g. converting natural lands to croplands to boost provisioning services but losing regulation and cultural services as large farms overtake other ecosystem types). Applying one of the seven principles for enhancing resilience of ES, "P7: promote polycentric governance systems," to this case allows examination of the relevant actors influencing the establishment of a just, resilient, and sustainable local food system for both humans and their natural surroundings (Biggs et al. 2012). As Biggs et al. state, "because different sectors of society often value, need and demand different ES, decisions about which ES to sustain are inherently political" (ibid.). Governance decisions must be informed by integrating ecological and social sciences, disciplines that "have evolved independently and do not combine easily" (Ostrom 2009). When it comes to governance over these decisions,

> Polycentricity refers to a governance system with multiple governing authorities at differing scales. Governance is defined as the exercise of deliberation and decision making among groups of people who have various sources of authority to act and may be practiced through a variety of organizational forms (e.g., bureaucratic department, watershed council, nonprofit organization). In polycentric systems, each governance unit has independence within a specified geographic area and domain of authority, and each unit may link with others horizontally on common issues and be nested within broader governance units vertically (Biggs et al. 2012).

While previous researchers has posited that "resource users will never self-organize to maintain their resources" (Hardin 1968) and therefore governments must impose solutions, more current research shows that "some resource users have invested their time and energy to achieve sustainability" (Ostrom 2009). Ostrom proposes a general framework of 10 variables that affect the likelihood of self-organization in achieving sustainable SES, which are relevant to the Lopez case. These variables are relevant to the study of any single SES, including the Lopez food system, and include: the size of the resource system (in this case, the farmland on Lopez Island), productivity of the resource system, predictability of system dynamics, resource unit mobility (e.g. how easily plants, crops, cows, and other resources can move within the system), collective-choice rules (e.g. how easily users can make decisions for themselves), number of users (in this case, farmers), leadership/entrepreneurship, knowledge of SES/mental models, and importance of the resource to users (Ostrom 2009).

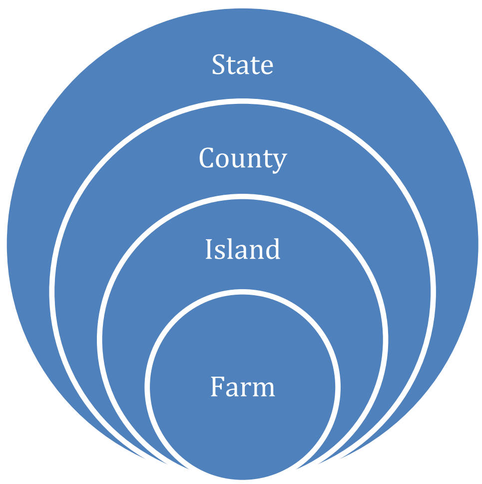

Figure 5- Polycentric Governance of Lopez Agricultural Activities

In the face of climate change and its accelerating impacts, solutions and strategies for adapting and mitigating climate change through island farming are clear. What is needed is governance structures and skillfully crafted policy (and economic) change to fund and scale these practices democratically. So, this chapter examines Lopez governance structures, from farms to island to county and state scales, and asks: What are the strengths and barriers to realizing a truly sustainable local food system on Lopez? How do perceptions of strengths and barriers differ or align among different governance scales? What are opportunities for immediate action or next steps to move towards the county vision for a sustainable local food system?

As Figure 5 illustrates, farms and farmers on Lopez are nested within island, county, and state governance scales. Farms can and do relate to each other horizontally, coming up with mutually beneficial and differentiated roles, responsibilities, and practices, where for example one farm may supply compost to others, while others provide woody debris back to that farm, and all farmers share strategies for eradicating common pests/weeds, taking care of animals in the absence of an island large animal vet, and securing inputs/supplies from both on island and off island sources (with a clear preference for sourcing inputs on the island). Farmers who raise meat share access to a USDA-inspected, certified organic Mobile Processing Unit for slaughtering animals on the island, the first of its kind in the nation and an example of polycentric governance involving island, county, and federal coordination. Each of these levels of governance are relevant to the conversation, research, and process of working towards a sustainable, equitable and resilient local food system on Lopez. Ultimately, state- and county-level political reforms are needed to unlock goals and changes sought by island organizations and farmers at the grassroots level, who are already attempting to self-organize to ensure sustainability of their SES. Governing and "understanding a complex whole requires knowledge about specific variables and how their component parts are related. Thus, we must learn how to dissect and harness complexity, rather than eliminate it from such systems" (Ostrom 2009).

2.2.3 Education: Strategies and Influences

In addition to policy and governance structures, education is a key component surrounding food systems that can unlock transformative change. In this case study, a range of environmental and food systems education research are relevant, most significantly: 1) farmer to farmer education on regenerative agricultural practices and 2) climate change education for youth, farmers, and the general public.

Farmer to farmer education is a cornerstone of the agroecological paradigm, which recognizes the vast knowledge stores held by experienced farmers as well as trust and value created when farmers share information with each other in horizontal knowledge transfers (Holt-Gimenez 2005; Altieri 2009). Farmer to farmer, or *Campesino a Campesino* networks are seen as essential to scaling up and out agroecological practices that "enhance the resiliency of agroecosystems" (Altieri et al. 2015). This educational form shares much with critical pedagogy, popularized by Paolo Freire in Brazil in the 1970s, which similarly emphasizes horizontal relationships between teacher and student, where both teachers and students are encouraged to ask and answer questions in an anti-oppression, anti-hierarchical "classroom" that aspires to higher goals of transformational social change and justice (Freire 1970).

Farmers hold unique and practical forms of knowledge that have developed historically in the United States context through both firsthand experience and institutions such as land-grant universities, Cooperative Extension, and the Farmer's Bureau. Farmer knowledge in the United States has become (techno)centralized in the hands of institutions and corporations who exercise power over large aspects of the food system, from production to consumption. This consolidation of knowledge is related to corporate consolidation and corporate funding of agricultural sciences in research institutions including land-grant universities and Cooperative Extension offices (Iles et al. 2016). Corporate and institutional influence over farmer knowledge and practices intersects with the National Farm Bill policies and system of subsidies and crop insurance, policies over which corporations also exercise influence, thereby dictating a pattern of mechanized, chemical-intensive farming that is practiced on a large scale in the United States, a pattern that is self-reinforcing. Unsurprisingly, as part of this top-down knowledge transfer funded by fossil fuel interests, farmers as a population demographic in the United States have been skeptical about human-caused climate change and expressed reluctance to take mitigative action (Niles and Mueller 2016; Gramig et al. 2013; Haden et al. 2012). However, there has been a notable shift recently due to extreme weather impacts on the Midwest and California (flooding and drought) that are making climate change a harder reality to ignore, and leading some farmers to declare that "farmers and rural Americans, that's who's going to solve this; We have the land for renewable energy, and we have the farming systems to sequester carbon" (Matt Russell, Iowa farmer quoted in Worland 2019). A farmer in Missouri informed *The Guardian* that "as climate change bites, farmers are increasingly accepting of the science as they are forced to spend more money on equipment and seeds to maintain current crop yields" (McGreal 2018). Importantly, research indicates that "farmers who were concerned about the impacts of climate change on agriculture were more supportive of adaptive and mitigative action and those who attributed climate change to human activities were more likely to support government action on mitigation" (Arbuckle and Lasly 2013). Experiential education in climate resilient agriculture for farmers will be important to translating research into action, enabling sustainable local food systems transformation.

Improving farmer and future farmer climate literacy is a crucial component of scaling and handing off climate friendly practices such as those identified in the literature (see Table 1), yet remains an area that has been underexplored in food systems research. There is little mention of training or educating farmers about climate change, and minimal mention in the K-12 educational arena of incorporating climate change into school food programs like Farm to School. Farm to School (FTS) programs refer broadly to environmental literacy in their education program element, but there is much room to grow for both FTS and adult beginning farmer training programs to incorporate coherent standards and curricula around climate literacy. Like all forms of environmental literacy, it comprises knowledge, attitude, and engagement/action dimensions (see "List of Key Terms" in Appendix for definitions). Concepts like environmental and climate literacy are notoriously difficult to measure and quantify but are nevertheless important educational objectives to build into both K-12 and farmer education spaces coherently through content and activities aligned with the best available science.

While the Lopez farmer population is already largely climate-engaged and active, the development of climate and environmental literacy among young people and aspiring farmers is important and in need of development, outlined further below and in Chapter 4, which focuses on education. The following sections apply literature on agroecology, agriculture and climate change, SES, and climate education to the past, present, and potential futures for the Lopez Island farming community.

2.3 Lopez Agricultural History: Linking Past, Present and Future

Historically, Lopez was an island of woodlands and native prairie, populated with Coast Salish communities who used regular burning practices to clear land for subsistence cultivation, hunting, and fire risk management. European settlers arrived in the mid-1800s, some fleeing the Irish potato famine to resume a life of farming and fishing on Lopez. Following the European theft of native land and the settlement of a boundary dispute between the United States and Great Britain in 1872, the islands were surveyed into 160-acre parcels and opened up to homesteading under the Homestead Act (Bill et al. 2011). Settlers from the Midwest arrived with cattle, sheep, pigs and chickens, and by 1908 Lopez had a commercial creamery shipping 1,500 lbs of butter each month to the mainland. By the 1920s the islands reach a high in number of farms and farmland, with 566 farmers and over 68,000 acres in production, largely for homesteading and subsistence purposes (Bill et al. 2011). Important crops included fruit orchards, strawberries, peas, and beef cattle eventually taking over from dairy herds after the 1948 milk regulations. Homesteading and horticultural production continued through the mid to late 1900s; total farmland acreage fell to its lowest point in the 1970s and increased again up until 2007. Of concern for soil fertility, hay production has been a significant component of farmland increase, contributing to soil depletion over time. Despite its small population size and total agricultural acreage, San Juan County ranks in the top half of Washington counties for value of sales from hogs/pigs and sheep/goats (USDA Census of Agriculture 2012).

Development pressures building up in the 1990s and 2000s began to adversely impact farmland and housing access. In 1989, the Lopez Community Land Trust formed in response to a rapidly emerging affordable housing crisis on the island, as home prices rose 190% in one year. The Land Trust immediately focused energies on fundraising and building affordable housing communities, breaking ground on the first set of homes in 1990, and eventually completing the award-winning net zero Common Ground community in 2006, recognized for its innovative integration of straw bale construction, local materials, rainwater catchment system, solar hot water heating, and community solar array.

The Land Trust adopted sustainable agriculture as core to its mission from the outset, recognizing the need to "provide permanently affordable access to land for such purposes as quality housing, sustainable agriculture and forestry, cottage industries and co-operatives by forever removing the land from the speculative market" (LCLT Statement of Purpose). In 1996 LCLT collaborated to bring the nation's first mobile meat processing unit to the islands to humanely slaughter animals, managed by the newly formed Island Grown Farmers Cooperative (IGFC). The mobile processing unit is USDA-inspected and greatly reduces costs (and effort) from transporting animals off island for slaughter. LCLT helped establish the Lopez Island Farm Education (LIFE) program in 2006, as well as a sustainable agriculture internship program that has funded and placed over 65 interns on island farms to learn regenerative practices for farmer-educators. LCLT initiated the Lopez Island Farm Trust (LIFT) in 2018 to preserve parcels of farmland in perpetuity, starting with the purchase of the historic Stonecrest Farm property for $1,000,000. LCLT's accomplishments are summarized in Figure 6.

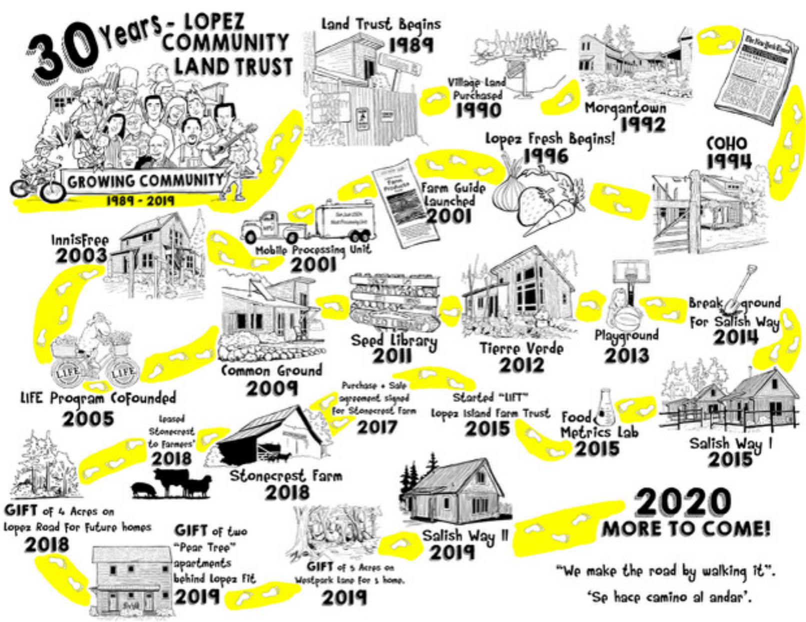

Figure 6- LCLT Projects

Today, farmers specialize in crops such as grass-fed meats, berries, tree fruits, diverse vegetables, grains, fiber, lavender and herbs, as well as value-added products including preserves, cheeses, ciders, and wines (Bill et al. 2011). Construction of greenhouses and hoop houses and commercial kitchens has enabled year-round production and preservation of the agricultural bounty. The average size of farms has decreased to 58 acres as the focus is more on small vegetable production than meat operations. Average market value of products sold per farm has decreased as well to just over $13,000, although once farm expenses are factored in, net farm income is -$6,293 (USDA 2017). Small scale heritage grain production has re-emerged on several islands, which represents an exciting step towards relocalizing important food supply chains and reclaiming sovereignty that has been taken away from communities through consolidation of food "commodities" (wheat being a prime example). Grains comprise the largest acreage of certified organic crop production in San Juan County at approximately 200 acres in production (although many farmers follow organic practices without being certified, an often-unnecessary step for within-island food marketing where so many consumers know and trust their farmers' practices). Grains also represent new revenue stream for farmers taking advantage of growing interest in sourcing local grains among local bakeries and restaurants.

A talk at the San Juan Agricultural summit in 2019 on farming history in the San Juan concluded with the statement that "it is a myth you can't make a living farming in the islands, but the successful people have been those who have innovated and shown their savvy at investing in new varieties or types of crop and in contacting distant specialty markets" (Pratt, February 3, 2019).

Looking to the future, continued access to farmland remains a strong concern for the agricultural community, as the island faces heightening pressure for development serving the summer tourism and second home markets, and the ability of the Land Trust to purchase other pieces of island farmland is limited by fundraising capacity. According to the LCLT website,

> After a decade of farmland loss throughout the San Juan Islands (USDA census records show a 27% loss from 2007 – 2012, followed by a 17% gain from 2012-2017), access to affordable, productive farmland is one of the greatest challenges that our region's farmers face. The average age of a farmer in San Juan County is 62. Who will farm? The majority of farmers in the County today have no plan for transferring their farm operation to the next generation, and for many, the value of their farmland as real estate is one of their greatest assets and a necessary part of their retirement plan. Farmland in San Juan County is indeed being preserved but not actively farmed. Repeated haying of preserved land doesn't increase soil health and fertility, and offers little variety for our table.

A 2011 report titled "Growing Our Future: An Agricultural Strategic Action Plan for San Juan County, WA" goes on to state that "appropriate state or local policies and regulations, as well as training, support, and resources are necessary to promote effective transfer, succession, and leasing of farmland for a new generation of farmers. Housing for these new farmers is a major issue as there are no code allowances for adding housing for succession farmers on existing farms, nor is there affordable housing available for new farming efforts on leased land." Changes to code language are needed to allow for farmland transitions to occur that provide affordable housing options for new farmers. Additional incentives must be put in place to facilitate the active and regenerative farming, rather than degradation and neglect, of farmland parcels.

When San Juan County farmland value is estimated at over $13,000 per acre (USDA 2012), aging farmers are facing retirement decisions, and farms are operating a net loss financially, the continued economic viability of sustainable agriculture is called into question. Challenges of aging farmers, attracting new farmers with interest in regenerative practices, and affordability of land and farmworker housing are familiar to farming communities nationwide. Lopez has an advantage in facing such challenges through its support network at the island and county levels: LCLT, the County Agricultural Resource Committee, Ag Guild, and WSU San Juan County Extension are active proponents and providers of technical assistance, policy support, financial resources, and outreach geared towards supporting current farmers and attracting new skilled agriculturalists to the island community. Such supports are essential to confronting these and additional challenges related to building a resilient local food system on a chain of islands.

When it comes to protecting farmland in the San Juans, the strategic action planning process in 2011 came to the conclusion that "success in protecting farmland will ultimately be defined not only by the amount of farmland conserved, but also by the productive, profitable, and **sustainable use of that farmland by local farmers**, thereby contributing to a strong, diversified economy that benefits farmers and their community, while also **building a viable and resilient local food system**" (Bill et al. 2011). Supporting "productive, profitable, and sustainable use" of farmland will require action steps outlined as report recommendations, including: 1) Adopt and promote scale-appropriate state and local regulations in order to foster farm businesses and support a thriving local farm economy; 2) promote opportunities for new farmers to establish successful farms; 3) develop adequate access to infrastructure necessary to process and maintain diverse agricultural operations; and 4) expand local and regional marketing opportunities (Bill et al. 2011). Members of the Ag Guild, ARC, and local agricultural stakeholders are working towards many of these goals, discussed further in the section below. Further partnerships are sought with conservation organizations to buy, conserve, and sell farmland parcels to those intending to farm the land regeneratively, meeting both conservation and food production objectives.

Members of the Lopez agriculture community have repeatedly mentioned the goal of establishing a new farmer training program, e.g. a "regenerative farm school" or other targeted farm incubator program that provides a combination of practical farming, business planning, climate change, and local context education to aspiring farmers. Models of such programs in the region include the Organic Farm School (OFS) on Whidbey Island, Viva Farms in Skagit County, and the Cloud Mountain Farm Center Internship (see a https://organicfarmschool.org/, https://vivafarms.org/, and https://www.beginningfarmers.org/cloud-mountain-farm-center-internship/). Many stakeholders express interest in adding to these types of training programs a deeper theoretical grounding in climate challenges and solutions in the farming sector. However, such programs can be expensive and difficult to maintain (as applications to OFS and Cloud Mountain have dropped off in recent years). They could be best served by accessing Land Bank or Preservation Trust land, if such a purpose were approved by these organizations, and partnering with other local food and farm organizations.

In 2012 a research team comprised of both island residents and graduate students from the Monterrey Institute for International Studies published a report outlining sustainability goals and improvements the island could make in sectors such as electricity generation, transportation, land use, and agriculture. This *Lopez 2025* report serves as a blueprint for achieving the island's progressive sustainability and climate goals. Later sections of this chapter will investigate the progress to date meeting the goals outlined the agriculture sector. The goals are stated as: host seasonal community events to promote local agriculture, collect and use treated sewage water for select

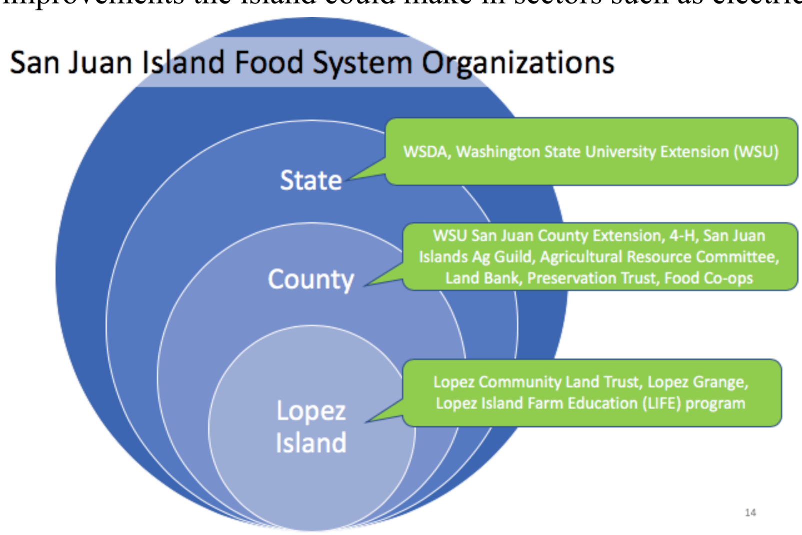

Figure 7- Food System Stakeholders in Polycentric Governance Model

crop irrigation, create a value-add communal industrial kitchen. promote local farmers through educational campaigns, build a co-op greenhouse, and form a local agriculture advisory committee. Integrating this report with the 2011 "Growing Our Future" report will surface common action steps and allow for updated planning in light of progress made over the past seven years.

Current trends and trajectories of Lopez sustainable agriculture are well documented in several additional publications around the 2010 decade. The LIFE program featured prominently in a publication from the Berkeley-based Center for Ecoliteracy, *Smart By Nature* as a promising example of "schooling for sustainability," part of the national movement of parents, educators and schools preparing youth to confront future environmental challenges. Local farm profiles came together in a visual, culinary publication put together by a team of island agriculture supporters, called "*Bounty: Lopez Island Farmers, Food and Community*." In the foreword to the book, author Vicki Robin of Whidbey Island reminds readers "local food is not a food system" (Robin in Graville 2017). Bearing this in mind, the Lopez Island food system project, led by many farmers featured in the pages of *Bounty*, is still a work in progress, supported by the organizations and stakeholders summarized in Figure 7.

2.4 Lopez Island Food System Sustainability Analysis: Evaluation of Physical, Natural, Social, Human, and Financial Capital

The literature on agroecology and sustainable food systems highlights critical factors for success in the domain of farming or food production, starting with affordable access to good quality farmland. Other essential "success factors" for sustainable and regenerative agriculture include cultivating soil health, minimizing external inputs, educating farmers to perform knowledge-intensive practices, and cultivating human resources to support agroecological transitions (Cummins 2019; Gliessman 2016; Carlisle et al. 2019; Pretty 2008). Jules Pretty describes five forms of "capital" that are important to building sustainable agricultural systems: physical, natural, social, human and financial (Pretty 2008). Following his presentation of agricultural sustainability, each of these forms of capital is considered and analyzed in the case of the Lopez Island food system in the sub-sections below which evaluate land access, soil health, use of inputs, farmer education, and human resources present in the form of farmers practicing regenerative agriculture. The analysis of physical, natural, social and financial capital is based off of informal interviews and conversations with local agriculture organization leaders as well as participation in island agricultural education events. The information on "human capital" is based off of semi-structured interviews with four island farms.

2.4.1 Land Access

The aging farmer population and farmland transition dilemmas on Lopez are challenges mirrored in agricultural communities nationwide, encompassing both large industrial and smaller scale operations. Several of the island's most successful farms are led by farmers in their 50s, 60s, and 70s, without a clear plan of who will take over as the current owner-operators seek to retire. Few of the farmers on the island have children interested in taking over the farm. The primary mechanisms for farm transfer and new farm establishment are through LCLT, the San Juan Islands Ag Guild, and the real estate market for island farmland.

LCLT works towards three goals related to land access: affordable housing, sustainable communities, and farmland conservation. Their most recent initiative, the Lopez Island Farm

Trust (LIFT), was formed in 2018 to spearhead farmland conservation work. LIFT aims to strengthen the local food system and provide affordable access to land through a "comprehensive legal, ethical, and economically viable land lease system." LIFT seeks to acquire, lease and manage new and historical farms; provide education for beginning farmers; foster business opportunities for regenerative agriculture operations; and encourage multigenerational living on the land (LCLT website). LCLT plans to use the affordable lease template as a model for securing and transitioning other farmland parcels, whether gifts or purchases, to the next generation of regenerative farmers. Ensuring the success of the newly leased Stonecrest Farm operation is essential to the continuation of this work, as facilitating a smooth transition to a new family operation is inherently challenging. It remains to be seen how replicable the Stonecrest Farm purchase is, or the degree to which it can serve as an affordable land access model, due to the difficulty for the land trust to raise large sums of money on a regular basis; "it was a big lift for us," says LCLT Community Liaison Rhea Miller, of the fundraising effort to purchase Stonecrest.

The Ag Guild recently received a three-year Beginning Farmer and Rancher Development (BFRD) grant from the USDA to research and improve access to farmland for new and beginning farmers. The grant collaboration included WSU SJC Extension, the Northwest Ag Business Center, Whidbey Island Conservation District, and the Organic Farm School (OFS) farmer training program on Whidbey Island. As part of the grant activities, staff at the Ag Guild conduct outreach with beginning farmers interested in accessing farmland and establishing operations in the San Juan Islands, and posts opportunities for farmland access on its website's "Farmers-to-Farmland" page (https://sjiagguild.com/about-the-guild/sji-ag-guild-programs/farmers-to-farmland/). The outreach process includes connecting farmers to suitable farmland parcels and providing relevant information about available water sources, markets, local contacts, and housing options. In some cases, aspiring farmers have decided that the location is not suited to their needs. Rather than seeing this as a failure, ensuring opportunity to opt out is an important part of the farmland succession process and ultimately setting up new farmers for success (Personal Interview, Peggy Bill, September 16, 2019). Recognizing and overcoming challenges of a specific context is an essential part of farmland transitions, with some challenges (e.g. finding suitable markets) more easily overcome than others (e.g. poor soil quality, lack of water infrastructure on some parcels, high land values and lack of affordable housing options).

In most cases, the land tenure for new farmers would be through lease agreements, rather than ownership models, as much of the farmland available in the county is owned by the Land Bank, Preservation Trust, or private individuals open to leasing arrangements with aspiring farmers. There is a divide between the landowning and land leasing populations, with many young people not able to afford to buy into an ownership arrangement. Currently on Lopez, most farmland in operation is leased rather than owned (Bill et al. 2011). This creates instability and precarity around sustaining the future of farming on the island.

Pathways to cooperative and collective ownership[5] of farmland as a land access opportunity are largely absent in the Lopez case study and throughout the Pacific Northwest. Ag

[5] Cooperative farming takes on many different forms, manifestations, and meanings in various circles, but here it is used to identify farming operations with multiple farm partners, land partners, or farm decision-makers who share a common stake in the farm. There may be a "head" farmer who bears primary responsibility for the financial wellbeing and overall farm activities, or there may be horizontal leadership structures where power is shared among a group of individuals, couples, or households. Cooperative structures are by no means a guarantee of greater farm

Guild staff are very open to the idea of supporting more farmers, both current and new, in establishing cooperative enterprises. Organic Farm School directors are similarly encouraging of this idea, arguing that many new farmers might not be ready to take over an 80-acre parcel of land and put it to productive use immediately, but it might be more appropriate for a group of five to divide up vegetable production, flower production, poultry production, grazing and value added products[6]. Distributing the risk, responsibilities, and knowledge-intensive labor among partners is a yet-to-be-thoroughly-tested strategy for overcoming some of the land access challenges facing farmers in the San Juan Island region.

2.4.2 Cultivating Soil Health

Agroecology rests upon an essential foundation of building healthy soil, through ecological cultivation of plants, insects, and food webs governed by the "Law of Return" creating a rich network of life on the farm. On Lopez, land clearing for farming, homesteading, and haying posed a threat to the island's biological and pedologic resource base starting in the late 19th century with the arrival of European-Americans. Today, there is growing attention around restoring and revitalizing soils, forestland, and ecosystem services. Farms such as Midnight's Farm are managing land for three purposes: healthy food production, economic viability, and soil carbon storage (Personal Interview, Faith Van de Putte, September 29, 2019). Other farms are following suit, seeking to build soil and revitalize land that has been degraded especially from repeated haying.

The soils on the island vary across short distances, from sandy and well-drained hilltops to heavy clay and moisture-retaining wetlands. The island geology is mostly rock, with a thin soil layer, not considered ideal for farming activities. In the words of one farmer, "we don't have much rich farmland for row crops on Lopez, so most of us are in a constant dance to balance income-producing crops with inputs to improve the soil and, therefore, the harvest" (Personal Interview, Christine Langley, September 18, 2019). Farmers and ranchers are involved in a suite of soil-building practices out of necessity for maintaining productive small-scale operations year after year. These practices include compost production and application, cover cropping, biochar production and co-composting, crop rotations, intercropping (e.g. undersowing a crimson clover crop amongst brassicas to provide valuable nutrients and reduces weed pressure), managed rotational grazing, minimal- or no-till cultivation, and combinations of perennial and annual plantings with animals to create a diverse ecological farming system that takes less than it gives back to the ultimate life-source: the soil.

Farmers receive support, training, and information from researchers at WSU SJC Extension, SJICD, and through annual farmer to farmer workshops. Several farmers collaborated in 2015 to host a visit from the Soil Carbon Coalition's Peter Donovan in order to sample local soils as a baseline and collect additional samples in later years to measure carbon storage, an important component of soil health. WSU researchers offer regular guidance and workshops

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viability and economic success; rather, they have begun to develop and promulgate legal documents to facilitate their existence in places such as Northern California and Vermont (where cooperatives are supported by groups like California Alliance of Family Farmers, California FarmLink, and local community land trusts).

[6] However, the Director of OFS has found that none of the farmer trainees in their 11 years of programming have proposed to farm collectively as part of their final business plan; everyone seems to want to "go it alone" and pursue their individual farming vision. She estimates that it will take "three successful examples in the PNW region of cooperative farming models, and they will probably be run by women, before the concept really takes off and people will be saying, 'Why weren't we doing this all along?'" (Judy Feldman, September 23, 2019).

around crop rotations and pasture management to improve island soils. Recently, WSU partnered with local farmers and the local bakery to host a Field Day on small scale grain production, part of a soil-building rotation that can enhance fertility in concert with legumes and other crops. Other WSU researchers collaborated on a successfully funded Western Sustainable Agriculture Research and Education (SARE) grant proposal with five local producers to explore the use of biochar co-composted with cattle bedding and other woody biomass materials as a soil amendment, which will be applied in experimental trial plots beginning in summer 2020 (see further information below). The SJICD received a WA State Department of Ecology grant to purchase a no-till seed drill that is shared among islands, and recently used in a sequence of liming and seeding Lopez pastures with diverse seed mixes to restore grassland soil health. While the support and education provided by local agriculture and conservation organizations is essential, there is a constant need for further financial resources to extend and improve educational initiatives and technology pilots.

2.4.3 Minimizing External Inputs

Related to efforts of building healthy soil through crop rotations and appropriate farming decisions, farmers on Lopez are taking steps to provide their own inputs for crop production that do not need to be imported or purchased from off island. A key local input is the high-quality compost produced at Midnight's Farm. At a Department of Ecology-approved facility, the farm produces compost from forest and agricultural debris dropped off from across the island, grinding, composting, and screening materials in an aerated static pile (ASP) system to create a finished product that is widely applied to local croplands. Manure and bedding material from the farm's cattle, pigs, and chickens are valuable feedstocks to the composting process as well. Midnight's produces over 600 yards of compost annually, which is all applied to Lopez agricultural lands and gardens. Farms also self-compost, recycling waste products in smaller decentralized systems and supplementing with purchased composts. Animals also play a role: "Our pigs really close the loop for us on the farm," one farmer stated, referring to food and plant scraps she was feeding to her American Guinea hogs who were in the midst of transforming it into high quality meat (Personal Interview, Meike Meissner, September 20, 2019).

More recently, due to wildfire risk mitigation efforts, the island has begun to selectively remove and burn some trees in a controlled, limited oxygen environment to create local biochar, a potentially valuable soil amendment with implications for increased soil carbon sequestration. Current production is happening at a very small scale, but regional interest in larger-scale biochar production abounds. Midnight's Farm initiated a research collaboration between WSU extension, U.C. Berkeley, and five local producers from across Western Washington to address the question: can biochar be a multi-use farm product that improves farm-based co-composted products and vegetable production, and promotes soil C sequestration? Two regionally sourced biochars (from both coniferous and deciduous woody biomass) will be applied to cattle bedding at Midnight's Farm, and then the biochar-bedding will be co-composted with other on-farm feedstocks to produce a biochar-enhanced compost product. Through absorbing Nitrogen and other nutrients from the cattle bedding, the "charged" biochar is intended to provide valuable fertilizer-like qualities to the compost, reducing the need for other amendments to cropping fields. The research hypotheses are: 1) blending biochar into cow bedding will result in greater N retention, reducing the potential for environmental loss, 2) adding the biochar bedding blend to compost will increase nutrient content, thereby adding value to the compost product, and that 3) compost with biochar as a feedstock will lead to increased soil carbon, cation exchange capacity, and pH when applied to soil (Collins et al. 2018).

The research team will measure impacts on manure handling, composting, soil quality and crop yields, following field application trials on two local farms (where the biochar co-composted will be evaluated alongside compost-only, biochar-only, and no-amendment plots, all cropped to cabbage). Data will be collected in Spring 2020 on soil profiles before amendment, and again in Fall 2020 on soils and crop yields. The research underway is based on prior work from local biochar researcher Kai Hoffman-Krull and others, who have worked with universities in Washington and Montana over the past five years investigating on-farm biochar soil amendments. They have found through field trials on nearby Waldron Island, WA, that in addition to improving soil C storage, locally produced biochars have potential to "significantly improve soil fertility and crop productivity in organic farming systems on sandy soils" (Gao, Hoffman-Krull, and DeLuca 2017). However, there remains controversy around the impacts of biochar in disparate contexts, evidenced by several meta-analyses pointing out varied outcomes based on pyrolysis and feedstock conditions (Brassard et al. 2016), and differential effects of in temperate vs. tropical soils (only tropical soils were found to have significant positive effect on yields as a global average; Jeffery et al. 2017). Both meta-analyses call for further study in diverse geographic contexts of interest. Pending outcomes of the local study on Lopez and across Western Washington, best practices for creating a locally sourced "complete" soil amendment could be scaled regionally, minimizing "external inputs" on a growing number of small-scale organic farms.

The goal of minimizing external inputs extends from farmers to others in the food supply chain, including island bakers of Barn Owl Bakery. Rather than purchase bulk inputs like sugar and wheat for their baked goods, Sage and Nathan are actively pursuing the local cultivation of grains and sugar beets to create their own 100% organic island grown products-- sprouted Lopez wheat locally milled into flour for wild leavened breads, fruit scones, flatbreads, and weekly specialties incorporating other island grown ingredients. Their work is also supported by local researchers from WSU Extension and a Western SARE grant to understand the impact of seeding rate and fertilizer application on the agricultural performance and baking quality of landrace wheat.

The goal of local input sourcing is also local waste management and reuse of waste as inputs into other ecological processes. Outputs from some farms (hay, woody material, compost, biochar) become inputs for others, in a cost-minimizing (occasionally non-monetary) closed-loop cycle for those involved.

2.4.4 Educating each other and the next generation

Transitioning food systems to agroecological practices will not be possible without investing in the "re-skilling" of an agroecological workforce. Lopez has a series of educational offerings in place to reach a variety of audiences from K-12 students to beginning and current. At the farmer-to-farmer level, Lopez farmers engage in regular meet ups and events, including the monthly farmer coffee. On the second Wednesday of each month, Lopez farmers gather at the Lopez Grange for an hour of information and resource sharing. Organized in 2019 by Faith Van de Putte, the forum is a meeting of the minds and transactional space for connecting problems with solutions, questions with answers. Where do people get good, affordable organic chicken feed? Who has straw for goat bedding? How do you get rid of persistent weeds like thistle and morning glory? Do deer get into the grain fields through the electric fence? How can we arrange for annual small animal vet clinics to provide appropriate care for our sheep, goats, and pigs? Disease and pest identification and management topics swirl around room, some finding mostly empathy, and others finding a speedier resolution. At a September 2019 coffee, several farmers shared positive results from experimenting with a new Organic Materials Review Institute (OMRI)-approved herbicide called "Weed Slayer," said to be effective against the pernicious thistles.

Underlying these informational exchanges is the challenge of continuing to run the iconic, diversified small farms of Lopez, lauded as beacons of sustainable agriculture and agritourism, yet requiring countless hours of hard work, determination and passion. Lopez farmers recognize that they cannot "go it alone" on their small farms and rely on the support of other farmers (seen as neighbors and friends rather than competitors) as well as researchers from WSU Extension. Two county extension agents were present at a recent coffee gathering to generate a list of future workshop and clinic topics to offer for farmers, as well as to gauge interest in collaborating on planned future research experiments, grants, and educational demonstrations.

In addition to educating each other, Lopez farmers educate aspiring farmers primarily through the Lopez Community Land Trust Sustainable Agriculture internship program. Each year on average five interns live and work on one of the islands six main educational farms, learning from the farmer how to seed, transplant, weed, water, and regeneratively farm diverse vegetable varieties and care for animals such as chickens, sheep, pigs, and cows. These interns select several readings and a documentary to discuss with other interns under supervision from Land Trust staff. Interns complement the practical and hands-on skills of farming with bigger picture reflection and dialogue about ideal vs. real food systems, connecting the production element to all the other moving parts of the system. According to the internship program director, the three biggest takeaways for participants are 1) importance of good local food, 2) basic life skills and 3) the experience of living in community. It is an "empowering experience;" however, it is not a formal or comprehensive beginning farmer training program and has thus far not led to the transition of farmland from an aging farmer to a former agricultural intern.

There are additional opportunities for young farmer mentorship through a Beginning Farmer and Rancher Development grant where more experienced farmers receive funds (up to $1000) to support and mentor younger farmers as they begin their own operations. This is geared towards new farmers who have already taken steps to start up operations on Lopez or other islands.

All farmers, new and old, have a recurring opportunity to learn more about evolving farm practices at the annual San Juan Agriculture Summit (Ag Summit), which rotates between Lopez, San Juan, and Orcas Island, and is held in February each year. The Ag Summit began nine years ago at the impetus of the Agricultural Resource Committee (ARC) and now WSU Extension has taken on the primary organizing role. Topics presented are wide ranging, from soil health to business and marketing to climate change, and feature speakers from all over the Western United States. The Ag Summit is a social as well as educational event, bringing farmers together for dining, dancing, and community building.

The education of young people is a crucial opportunity for scaling agroecologial practices. On Lopez Island, farm to school programming is run through the Lopez Island Farm Education (LIFE) program. It began as a collaboration between LCLT, the Lopez Island School District, Lopez Island Education Foundation, the Family Resource Center, S & S Center for Sustainable Agriculture, the SJI Conservation District, WSU SJC Extension and the Heller

Family. The program uses an "integrated systems approach" to delivering hands-on education in nutrition, ecology, sustainability, and land stewardship (LCLT website). In practice, this consists of educating students in a garden classroom elective for elementary and middle school, hosting a high school farm elective course where students visit local farms, and preparing and preserving food from the school farm in the cafeteria, where local scratch-cooked meals are served year-round. Part of the growing national movement around improving the quality of school meals through locally sourced produce, the LIFE program takes advantage of the exceptional quality of both locally produced foods and farm-based educational opportunities on the island.

The LIFE program has been funded by a combination of a large private foundation and smaller donations, fundraisers, grants, and in-kind contributions. It is currently working towards a more sustainable, diversified finance model that will expand those invested in the program's success as well as allow the educational activities associated with LIFE to grow. LCLT coordinates interns to support the LIFE program in the summer (funded by the Heller Foundation), and staff at the Family Resource Center run a volunteer-based gleaning operation on island orchards that yields up to 5,000 lbs. of fruit for the school cafeteria. Production has grown steadily at the ½ acre school farm, from 1,400 to over 6,000 lbs. between 2009 and 2016 (see Figure 8). The program is currently fundraising to purchase two beef cows raised by island teens for the cafeteria meat supply.

Participating in the LIFE program as a sustainable agriculture intern in 2015 prompted the following research questions about the level of environmental literacy among student participants. I sought to answer the questions:

1. What are current educational practices of farm to school programs in the San Juan Islands to address and improve student environmental literacy?
2. What are the environmental literacy outcomes of students participating in farm to school programs?
3. Are programs meeting other goals (procurement, health, nutrition, garden establishment) to a greater degree?

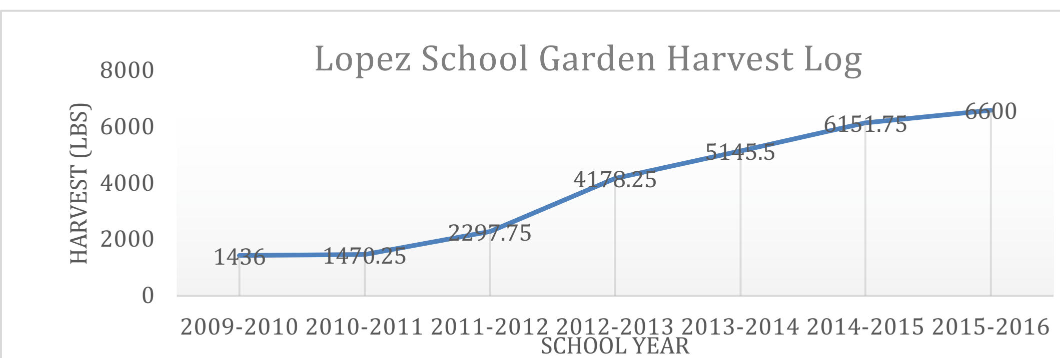

Figure 8- Lopez School Garden Harvest, 2009-2016

The results of this research investigation led to the conclusion that students were not yet connecting their experiential learning activities in the school garden to bigger picture environmental themes and challenges, such as climate change, greenhouse gas emissions, and the environmental impact of conventional food systems. The gaps in environmental knowledge, which forms an important but not complete piece of the environmental literacy equation became clear to teachers at the school, who sought to fill those gaps with new curricula. In partnership with Lopez school and LIFE staff, I developed a food systems and climate change 6-lesson curriculum, designed to engage students in questions at the climate and food nexus. The curriculum walks through the causes, effects, impact monitoring, and solutions to climate change, through the perspective of the food and agriculture sector. The culmination is a class or school-wide climate action project in partnership with the community, sparking informed hope through taking action. This curricular outcome of the LIFE program is evaluated and discussed further as a pathway to farm-based climate education and applied to other school contexts in Chapter 4.

In addition to assessing environmental literacy outcomes, environmental impacts of the LIFE program were also investigated in 2015-2016. Using the Cool Climate Carbon Footprint Calculator for food-related emissions, eliminating the need to transport all meat, fruits and vegetables to the school could save 1.4 tons CO_2 annually per person. Adjusting this metric to account for the 9-month school year and multiplying by approximately 120 students who eat at the school cafeteria per day, this yields approximately 120 tons of CO_2 savings annually.

K-12 education is inherently social. The director of the Organic Farm School finds hope in the very nature of children working together in school gardens, that they might come to see farming as more social and collaborative, and thus more readily forge pathways into cooperative farming.

2.4.5 "Human resources" on Lopez: Learning from established farmers

Integrating the "success factors" listed above (land access, soil health, minimizing external inputs, and education), farmers provide additional insights into the sustainability of their operations.

Midnight's Farm

Midnight's Farm, a 100-acre property located near the center of Lopez Island, heralds the diversity of its operations from the initial entry point down a gravel driveway. A signpost indicates the direction of the compost operations, yoga studio, farm stand selling beef, pork and vegetables, and wood-fired bakery (soon to be moving offsite). In the words of the farm owners, "we farm to steward this wonderfully beautiful piece of earth and for the tangible, hands-dirty love of connecting people to the soil and storing a little bit of carbon there, too." The land was purchased with savings from a previous career as an Alaskan salmon fishing captain, and the past 20 years have seen a progressive investment in land restoration and diversified agriculture operations. From the establishment of hundreds of trees at the property border to rotational grazing plans for cows on pasture and marshland, to fruit trees and ¼ acre home garden with greenhouse, to a blueberry patch being prepared for planting in 2019, biodiversity continues to grow.

Revenue streams are accordingly diverse, with the compost and woodchips bringing in the most revenue annually, followed by Field House vacation rentals, beef and pork products, and vegetable sales. The Field House, available for short term farm stays, hosts visitors year-round and is booked throughout busy summer tourism season, capitalizing on the growing market for agritourism opportunities.

The farm has typically provided housing for another couple in a barn apartment, in exchange for regular workdays or some combination of paid labor and housing work-trade. Sustainable Agriculture Interns coordinated by LCLT help out during summer months, and the farm is a popular destination for "WWOOFers" as well (those participating through the international World Wide Opportunities on Organic Farms program). Other Lopez Island youth work on the farm several days a week during the summer. At maximum capacity, the farm hosted nine farm employees during the summer 2019 season.

Farming practices are the product of decades of experience, and soil fertility is the product of countless yards of compost and mulch application. In the vegetable garden, dozens of crops feed the farm families and neighbors each year. From spring seeding to bed preparation and transplanting, to weeding, irrigation, harvesting, cover cropping and winter greens cultivation in the greenhouse, every activity has its seasonal rhythm. Several planting strips are gradually converting to no-till farming, with compost, mulch, and broad-forking substituting for the mechanical mixing of the soil. Tilling is associated with carbon release and disturbance of the soil biota, so reducing or eliminating tillage is an effort several farmers are working towards, in balance with weed management. Irrigation ponds, dug on most farm properties, fill up with rain in the winter, and provide water to crops through the dry summer months. Pasture area is grazed rotationally and managed for optimal plant biomass communities. It is amended with lime and seeded with beneficial plants to boost nutrient quality of forage materials. The cows contribute to the regeneration of pasture soils, providing aeration from their hooves, growth stimulation from grass consumption, and fertilizer from their manure.

David and Faith, the owners of Midnight's Farm, are passionate about researching and implementing agricultural solutions to climate change on their farm. Their bookshelves are filled with books such as *Grass, Soil, Hope*; *Dirt to Soil*; and *Growing a Revolution: Bringing our Soil Back to Life*, and their social calendar is filled with attending climate talks and hosting climate researchers from University of Washington (UW), WSU, and other institutions. Most recently they are engaged in a carbon footprint analysis of their compost operation, land use, and cattle herd, in order to understand highest-impact opportunities for emissions reduction and carbon removal. The results show that currently the farm is contributing to the sequestration of approximately 250 $mtCO_2e$, via forest cover, marshland, managed pastures, compost production and application, which together more than offset emissions from farm machinery, diesel use, and cattle (enteric methane emissions and slaughter/processing emissions) as shown in Figure 9.

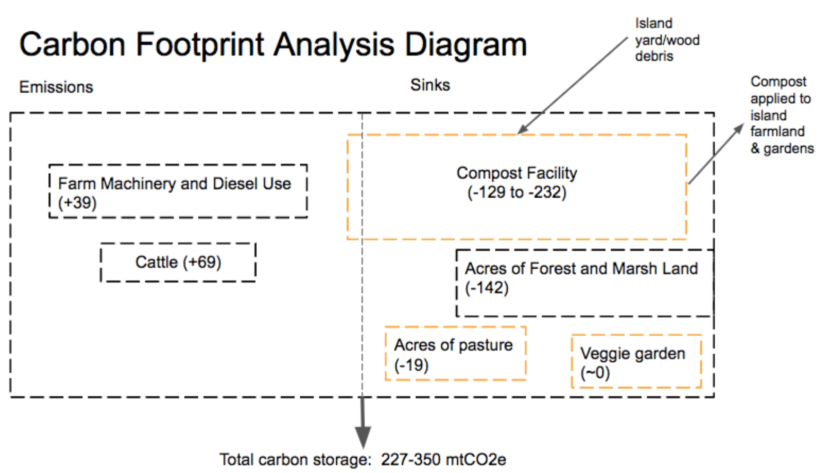

Figure 9- Midnight's Farm Carbon Footprint Analysis

David and Faith advocate for a "big tent" approach to food systems transition where many different people and groups can see themselves in a process of growing food with a lighter climate impact, and better human health impact. Their vision rests on a premise of developing strong interpersonal relationships, infusing the work with joy, humor, social connection, and opportunities for personal growth. An onsite yoga studio offers space for interns and farming friends to stretch and reinvigorate bodies feeling the effects of hard physical work. David and

Faith continue to articulate better and brighter ideas for the future, such as finding long-term land partners and helping launch a climate farm school on the island, pushing forward the vision of a truly regenerative agroecosystem on Lopez.

Lopez Harvest

Orderly rows of greens and vegetables lend a sense of efficiency and purpose to the fields of Lopez Harvest. Successional plantings of diverse lettuce varieties march westward across the field, with the largest plants cut for weekly harvests while each neighboring row showcases one fewer week in the field. 500 lettuce plants go in the ground on Wednesdays, and plants are harvested on Tuesdays and Fridays for twice a week deliveries. The humming schedule of running a successful greens production farm serving the two island grocery stores as well as 5-6 island restaurants and food businesses creates a strong weekly rhythm for farm owner and farm workers. Dig, transplant, bed down, repeat. Six inch spacing, four rows per planting bed. Finish the row, water it in, keep moving.

Lopez Harvest sells lettuce mix, a specialty blend of "Island Greens," chard, microgreens, arugula, herbs, and various seasonal vegetables and specialty crops to most of the for-profit food retail and business operations on the island. Christine, the farm owner, sends out a "pick list" to all customers a week in advance, takes orders by a certain day, and harvests and delivers all orders herself. This is her answer to the question "what does it take to be a successful small-scale farmer on a small island?" She sells her surplus produce directly to retail and restaurant, finding this to be more profitable than selling at the seasonal weekly Farmer's Market or direct to consumers. She raises additional vegetables for personal consumption, reducing her own need to purchase store-bought foods, and facilitates a meat-share program where costs and benefits from raising meat chickens are shared among participating households. These non-monetary and cooperative forms of exchange are important to the economic viability of her operations. Christine now receives additional revenue from her participation in a beginning farmer mentoring program, where she earns up to $1,000 annually for mentoring younger farmers in their first year of operation (the program is funded by a BFRD grant won by WSU Extension). Her farm is on shared land purchased by three couples, and was acquired with family support, a common method for overcoming high barriers to entry for farmland access (at least, among farmers from higher-income families).

While some rows of her field are planted to commercial crops, others are in rye-vetch cover crop mix gaining fertility for next year, or mustards to deter wireworms. The cover crop is mowed down and incorporated into the beds, with some beds serving as experiments for no-till practices where she has also tried occultation techniques to germinate and kill weeds prior to transplanting. This is difficult to enact on her land due to heavy clay soils that need some disturbance to be made ready for tender transplants and is a work in progress. Commercial crops are rotated onto previously cover cropped beds, a dance between production of plants and soil. In Christine's mind, "good farming is good for the climate;" she adopts practices when they prove beneficial for her land, crops, soil, and business model, and it just so happens that many of these practices are anointed in academic research as climate mitigating strategies.

Christine exemplifies a successful independent, woman-owned business model. She receives seasonal labor support through the LCLT intern program and through informal work-trade agreements with friends and neighbors. Christine is a vocal contributor at the monthly farmer coffees, sharing what she's learned about effective weed control strategies (from certified organic products to biological and ecological methods of controlling weeds), and a gifted farmer-educator. She collaborates with WSU San Extension on a research project to reduce wireworm pest pressure in lettuce crops and is also a collaborator on the Western SARE biochar co-compost grant, participating in the field trial and soil/crop data collection processes.

Christine recognizes the attractiveness of entering into farming cooperatively or with farm partners but struggles with the difficult proposition of supporting multiple households with limited farm revenue streams and land use restrictions. When it comes to sharing land in her current situation, she would love to be able to build and provide more farmworker housing, but is restricted from doing so by county zoning policies that prevent more than two houses from being built on a parcel designated as "farmland[7]." The county zoning codes are ripe for reform, but notoriously difficult to get right in terms of regulatory verbiage that protects farmland from becoming housing developments yet allows for ample and affordable farmworker housing. Currently grappling with her own problems of farmland succession, scaling back, and transitioning her land, Christine hopes that the land can continue to be farmed, while still allowing her and her partner to extract their equity and support their own retirement. On the way to working out these details, Christine continues to get up early each morning of the summer, turn on the irrigation system and harvest high-quality vegetables, sharing her beautiful food production space and boundless stores of knowledge with those seeking it in her community.

Stonecrest Farm

Meike Meissner and Mike McMahon moved to Lopez Island with their three children in spring 2018, after signing on to a 15-year long term affordable lease of Stonecrest Farm through LCLT. Meike and Mike got their farming start in California, where they both worked at the Occidental Arts and Ecology Center. They grew their experience in the American West, participating in a rangeland internship in Montana and establishing an award-winning contract grazing operation in Colorado. Thinking holistically and with climate change in mind, Meike and Mike practice a combination of farming and conservation work. They are both trained in managed grazing through Holistic Management International, an offshoot of the Savory Institute, and believe in the value of animals as regenerative elements for degraded rangeland.

Upon moving to Lopez, they have faced inevitable start-up obstacles in establishing pasture-raised heritage pigs, rotationally grazed beef cattle, chickens, and kitchen processing facility. The pasture areas have been so degraded from repeated haying that there is little nutritious forage available for their cattle operation, which they would like to be 100% grass-fed and finished, with no supplemental hay fed to their animals. Before this is possible, they must regenerate the available forage and bring back high-nutrient plant biomass on their land, through a creative, locally tailored approach to grassland ecosystem restoration. In the meantime, they are leasing other land for rotational grazing of their beef cows. Adding to the quandary is decades of selective cattle breeding in the United States to maximize high-protein feed-to-meat conversion as quickly as possible. Venturing into the field of epigenetics, Meike laments the fact that there are few cattle breeds in the U.S. particularly well suited to convert poor forage to high quality meat, which would represent another opportunity for minimizing external inputs in the form of supplemental animal feed.

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[7] Ag land allows for one residence and one guesthouse; farmworker housing is allowed but specific requirements can be difficult to meet.

Meike spoke at length about her abhorrence of using anything the comes wrapped in plastic and avoiding petroleum products in farm operations wherever possible. When it comes to removing and controlling weeds in their home garden without chemicals, tillage, or black plastic cover, there is a seeming dearth of options remaining; however, a return to natural methods and materials such as hugelkulture beds, permaculture principles, and sheet mulching with cardboard, wood chips, and tons of compost offer promising potential. Meike and Mike think in terms of returning all waste products as inputs to some other farm process. Dead weeds become organic material for building soil, inedible food items become high nutrient components of their pigs' diet. They are on a challenging path toward land regeneration first, ideally unlocking food production and economic viability down the line.

Sweetbriar Farm

Doug Benoliel and Tamara Buchanan are among the most knowledgeable and skilled people to be producing and distributing diverse vegetables to the Lopez Island food bank (Lopez Fresh). After 25 years of running a successful plant nursery in Kirkland, WA, the couple "retired" to Lopez Island to start their own farm. Doug has a degree in botany from UW and wrote a book titled *Northwest Foraging*, and Tamara has exemplary culinary skills that she developed through self-guided experience. With a 5-year crop plan in hand, they began diversified vegetable production at Sweetbriar in 2011, cultivating an array of seed varieties for each crop (up to 13 different lettuce varieties were grown in 2015). They hired LCLT interns for several summers and recruited an additional crew of volunteers to help out with farm harvests and multi-person chores weekly, on Fridays throughout the growing season. Produce was sold through a farm stand at the end of the driveway, a CSA subscription, and at the island Farmer's Market for a few seasons. However, due to personal health conditions and a series of operations, Doug and Tamara had to scale back from production-sales operations. They currently run a scaled-down farm and do not sell any vegetables; all of the harvest is used for self-consumption and processing or delivered to Lopez Fresh and specific families in need (roughly 80% of the harvest is donated). Volunteers still come by several times a month to bring in the harvest and package it for delivery to the food bank and take home vegetables for their families.

This donation-based model of farming is supported by the farm owners' personal wealth from previous careers and life pursuits (Tamara is also a renowned sculptor, selling her work across the Pacific Northwest). It rests on the recognition that many of the island-grown vegetables and specialty products are unaffordable to large sectors of the island population, who work in the tourism industry and do not own land. Food insecurity in San Juan County is estimated to affect 39% of residents, according to a United Way of the Pacific Northwest ALICE report in 2018. The island food system as a whole is precarious, and not equitable, when such large percentages of the population cannot afford to access nutritious, locally produced food.

It is unclear how long Doug and Tamara will continue their mission of supplying Lopez Fresh with produce from their farm, as they are in the active process of scaling back and downsizing. Doug has offered up space for gardening on his land to other individuals, but so far no one has taken him up on the offer, for a variety of personal circumstances. Whether other farms will follow suit in donating produce as they exit market-oriented production is an open question, which might require policy incentives and nudges to facilitate a more robust food donation system. The volunteer-based gleaning operation run by the Lopez Island Family

Resource Center (LIFRC) and the LIFE program[8] are two other examples that donate fresh food to low income families. Addressing food security problems with donations of food serves an important interim purpose, but larger policy and economic changes, in the form of increased living wage jobs and affordable housing, are needed to address the root cause (poverty and systems of inequality).

2.5 Summary of Opportunities, Challenges, and Next Steps for Building an Equitable and Sustainable Local Food System

In light of the data collected on the Lopez food system, opportunities and challenges for each food system element are summarized in the tables below. An additional table summarizes the progress to date towards the goals of the *Growing Our Future* and *Lopez 2025* reports. This section concludes with recommendations for county and state policy.

Table 2. Production

Opportunities	**Challenges**
Geographic isolation- impetus for food self-provisioning and organic seed saving	Cost of inputs, including skilled labor
Talented/knowledgeable community of farmers	Lack of sufficient farmworker housing
Collaborative farmer community poised to work together to meet shared needs, e.g. establish co-op greenhouse (if this is still a shared goal)	Cost of farmland- difficult pathways to ownership (especially for low income and minority groups lacking family wealth or personal savings), more common to lease land (could discourage investments in land over the long term without appropriate long term leasing agreements)
Land trust and conservation group work to acquire farmland; Long-term lease agreement model e.g. LIFT program	Poor soil quality

Two of the three farms highlighted in the section above acquired farmland in the first place due to wealth transfers from previous careers or family members. The value proposition of purchasing farmland and paying off debts through limited farm incomes is otherwise extremely difficult and disadvantages low income and minority groups who have been excluded from generational land and wealth accumulation. There is not yet a “social safety net” in place to enable farming as an equal-opportunity, financially viable or desirable career pathway, in terms of guaranteed income, health care, and time off to support personal wellbeing. This is preventing the easy transition of farmland from current to new farmers and causing hesitancy among young people seeking to make an early career as a farmer in the San Juan Islands, ultimately challenging the sustainability of agriculture on the islands as a “way of life.” In order to avoid a

[8] Over 80 volunteer gleaners harvested over 10,000 pounds of fruit for donation in Fall 2018. Farm managers of the LIFE program routinely send students from low-income families home with backpacks full of food for the weekend.

situation where only the wealthy can afford to farm sustainably, policy mechanisms must be put in place to democratize land access. Promoting and facilitating cooperative ownership and buy-in to farmland is something the county has yet to address effectively; it is challenging, and yet a promising action step for enabling successful farmland transition for a more diverse array of new farmers (including those from less privileged backgrounds).

Opportunities exist on the production side of the Lopez food system in the form of local knowledge accumulated over decades of implementing sustainable and regenerative, agroecological practices, that is ripe for sharing and transferring to new and beginning farmers through mentorship programs or the establishment of a more formalized "farmer training program" on the islands. Additionally, on the land acquisition front, the LCLT long-term affordable lease model piloted with the Stonecrest Farm purchase could lead to other transfers of farmland at low cost to new farmers (note: this is contingent upon overcoming the initial barrier of fundraising to acquire new farmland parcels).

Table 3. Distribution

Opportunities	**Challenges**
Sharing distribution channels or aggregating product among farmers	Getting product to markets, especially off island (expensive); Fractured island geography, isolates some producers from distribution outlets (wholesale customers, restaurants, other islands, etc.)
Larger-scale San Juan Islands Food Hub project, with an existing business plan developed by the Ag Guild and partner groups, in progress	Difficult to establish a successful CSA distribution as many residents have personal home gardens and summer visitors don't want to buy in for the season
Farmer's Market- currently evolved into more of a crafts market, room for more farmers to participate	Accessing a shared refrigerated truck
Ability to trade food for other goods and services on the island without monetary exchange; local trust and relationships enable flexible transactions	Integrating equity into Food Hub business plan

On a small island such as Lopez, there are opportunities to share and collaborate on distribution activities especially for complementary products. However, the limited number and size of markets could prohibit entry into a channel that is already dominated by one farmer or food business; therefore, diversifying and coordinating with other farmers is an opportunity to streamline distribution activities. Opportunities exist for farms growing fruit to partner with and distribute alongside farms growing vegetables, meat or dairy products, which would be expedited by access to enabling infrastructure such as a shared refrigerated truck, aggregated cold storage, and designated food delivery person to transport products from farms to customers and retail locations. Ideally a shared transport system could be optimized to reduce vehicle miles traveled for food distribution, and a transport vehicle could be a hybrid or electric model to meet local goals of carbon emissions reductions in all facets of the food system.

Efforts to streamline distribution exist in the form of the proposed San Juan Island Food Hub, which would provide institutional support for aggregating and distributing farm products between islands, improving transparency between producers and food purveyors. According to a 2015 Food Hub Feasibility Study led by the Ag Guild and ARC, there is a strong desire and opportunity for a San Juan County Food Hub to provide an online platform for ordering, aggregated cold storage, and aggregated purchase opportunities that would help meet the unmet demand for local food products in restaurants, grocery stores, and other food businesses[9]. Most farmers currently do not have the time and capital to transport their produce to other islands but stand to benefit from accessing these additional markets. The food hub project is in progress and could be expedited with funding and community support. While food security is a stated goal of the project, it is unclear how increased access and affordability to low income consumers would be accomplished, other than through assumed improvements to local economic development and job creation. A specific plan for meeting the needs of low-income residents in the activities of the food hub would be a valuable improvement to the current planning process.

The Lopez Farmer's Market is an opportunity for farmers willing to participate weekly throughout the summer, as farmer participation has dwindled in recent years and there is interest in attracting more farmers to sell at the market. Finally, the close-knit Lopez community breeds the trust and interpersonal relationships that facilitate many non-monetary forms of exchange, whereby farmers can trade food products directly for other goods and services they may need from island residents, in mutually beneficial trades that create solidarity and sovereignty from financial institutions.

It is challenging to establish a successful CSA distribution on Lopez, requiring farmers to think creatively about how to structure weekly shares in a way that provides products that many residents do not grow for themselves, and accounts for the shorter-term seasonal demand of summer visitors.

Table 4. Retail/Marketing

Opportunities	**Challenges**
High volume of sales potential for summer tourism industry	Lack of inter-island distribution channels*
Off island markets, if costs were to come down or aggregating among farmers shared costs	Limited market transparency (clear information exchange between farmers and buyers)*
Farm to school/farm to cafeteria programs	Limited market coordination *
Restaurants and food businesses prioritize local food procurement	Purchase of Puget Sound Food Hub produce at lower prices than Lopez farmers can compete with threatens some existing marketing channels

*Identified as market challenges in the 2015 Food Hub Feasibility Study

There are limited retail establishments on Lopez, many of which have outstanding relationships with specific farmers to supply certain goods. This can create a barrier to entry for

[9] 80% of food purveyors in San Juan County would increase their purchasing of local food if an efficient distribution system and online platform were available through a food hub.

new producers, who must either provide something that is not already present in the retail environment or establish affordable marketing opportunities off island (either independently or in collaboration with other farmers, or through the emerging Food Hub project). The school cafeteria is seeking to procure more locally sourced meat and dairy, providing a retail opportunity for producers of those products. As new restaurants, food trucks, and food businesses come to Lopez (e.g. Poutine food truck, Noodle Bar, and Ursa Minor), new retail opportunities inevitably present themselves to farmers given the culture of prioritizing local food procurement.

Table 5. Processing, Preparation and Consumption

Opportunities	Challenges
Commercial kitchens- Taproot and Fork in the Road projects	Assembling all necessary infrastructure (e.g. grain milling and cleaning equipment, drying facilities, cold storage space)
Local desire to consume locally produced foods year-round	Food Safety Certification requirements
Local knowledge of processing techniques	Value-added processors in particular seek additional off-island and regional markets
FoodSafety Metrics lab- purchased by LCLT to allow local food businesses opportunity to test their food for safety purposes	

The processing opportunities have been an active area of progress for the past several years, leading to the establishment of two commercial kitchens on the island. One is privately owned and accessible to island growers who sell their products commercially, and another is available for public use. There is a strong community desire to consume local foods year-round, supporting the expansion of the processing and preparation sector, and abundant local knowledge of creative processing techniques that could be taught or shared in community workshops. Additional cold storage is required to allow for local fruits in particular to be consumed six months out of the year, rather than just two. Food safety certification and training is required for all users of commercial kitchens and for the kitchen itself, which is time-consuming and expensive.

Table 6. Waste Management

Opportunities	Challenges
Expanding compost operations on Midnight's to include higher-quality biochar co-compost product, reducing local woody biomass debris	Sourcing inputs and exporting non-compostable waste materials off island is expensive
Delivering/recovering food business waste to local farms for animal feed or compost piles	Plastic recycling no longer accepted at island waste facility- need to reduce use of plastics

“Imperfect” produce and seconds can be processed or donated for school meals program or island food pantry; scaled up through active island “gleaning” group	

Waste management is already fairly streamlined on Lopez due to the expense of transporting waste products off the island, and the organization of the award-winning solid waste facility (“the Dump”). Current opportunities for improvement include the local biochar production and co-composting effort, as well as maximizing food waste recovery from all island retail stores and restaurants to be returned to local farms for composting. Food recovery from the fields and orchards occurs through a volunteer-run gleaning program, which could be scaled up with further support or participation incentives. A significant challenge for farmers is to reduce all plastic use and substitute with alternative materials, as plastic is no longer accepted at the Dump for recycling and must be paid for at time of disposal.

Table 7. Education

Opportunities	**Challenges**
Interest and location ideas for establishing a beginning farmer training program with a climate education element; local programs to serve as examples (e.g. OFS, Cloud Mountain)	Time, availability of, and ability to hire skilled farm-based educators
Build on food systems and climate change curriculum to improve climate literacy among Lopez students	Defining education program goals that are realistic and accounting for countywide land access challenges
Existing channels for farmer to farmer learning at farmer coffees and annual San Juan County Agriculture Summit (Ag Summit), good existing forums for sharing information	
Many guest speakers and workshops already happening on the islands (often organized by WSU Extension)	
Young student farmer education or Young Farmer leadership program- countywide to expose actively farming young people to new practices and skills needed to succeed	

In order to build a climate-themed farmer training program on Lopez, fundraising and/or grant-writing is needed to bring together land and human resources to execute such a program. Hiring a skilled farm-based education and other staff to support educational efforts is a challenge that must be worked out before this opportunity can be realized. Improving upon the K-12 food and climate education efforts at the school is a more easily accomplished opportunity through partnership and participation of more farms and educated adults on the island. Additionally, recognizing that several young people on Lopez are already actively farming and interested in doing so in the future presents an opportunity to strengthen countywide Young Farmer leadership programs in order to expose these aspiring young farmers (age 14-18) to new practices and skills needed to create successful farm operations.

Progress Towards Lopez 2025 and “Growing Our Future” report goals

Thus far, the Lopez food system transformation has made concrete progress on four out of the six stated goals from the Lopez 2025 report, and three out of four of the "Growing Our Future" action steps (see Table 8). Next steps for governance actions are highlighted in red.

Table 8. Progress Towards 2011-2012 Goals

Lopez 2025 Ag. Goals	Progress	Growing Out Future action steps	Progress
Host seasonal community events to promote local ag.	LCLT Annual Harvest dinner, winter Ag Summit, seasonal "evening meals at school" by Lopez Locavores, Farm Tours	Adopt and promote scale-appropriate state and local regulations to foster farm business and support thriving local farm economy	Insufficient progress to date.
Collect and use treated sewage water for select crop irrigation	None to date *This remains a controversial "goal" as many have concerns over safety and appropriateness of treated sewage use for food crops	Promote opportunities for new farmers to establish successful farms	In progress, supported by BFRD grant; will need more funding to continue program
Create a value-add communal industrial kitchen	Taproot community kitchen and Fork in the Road commercial kitchen projects	Develop adequate infrastructure necessary to process and maintain diverse agricultural operations	In progress through commercial kitchen and other infrastructure projects + proposed Food Hub
Promote local farmers through educational campaigns	Annual farm tours, and farm to school programs, could be more of a "campaign"	Expand local and regional marketing opportunities	In progress- San Juan Food Hub project
Build a co-op greenhouse	None to date		
Form a local agriculture advisory committee	This exists in the form of the Agriculture Resources Committee (ARC)		

County Policies and Economic Practices

Using data gathered from interviews and observations of current farmland operations on Lopez and referring back to Ostrom's ten variables, it becomes clear that farmer self-organization to sustain the local food system is very likely (see table in Appendix A.1). Nevertheless, the propensity for farmers to self-organize does not guarantee that the more complex and overarching political and economic challenges will be resolved through grassroots self-organizing; farmers must integrate and collaborate with other circles of the polycentric governance structure in which they are nested to adopt necessary reforms. The ARC, for example, is a Citizen Advisory Committee tasked with advising the County Council on issues affecting the Agricultural environment comprised of 15 voting seats, at least 50% of which must be farmers. It is currently seeking to advance the goals expressed by farmers for favorable county land use policies through promoting the adoption of an "Agriculture" specific section of the Land Use Element of the Comprehensive Plan, currently under revision.

A revaluation and realignment of county policy and political economy are needed to accurately account for and support the endeavors of the Lopez agricultural community. Currently, revenues from sales of local food products comprise roughly 2% of total county revenue (see budget chart). However, farms are contributing so much more to the island economy than sales of food products: they are attracting tourists, educating community members at farm tours, quantifying efforts to sequester carbon on working lands, creating resilience to off-island food supply chain disruptions, building community health, and weaving a fabric of community land ethics that infuses the Lopez "sense of place." Tourists, local residents, and restaurants alike attribute their desire to come to the San Juan Islands in large part to the local food scene and pastoral island character. If the county is able to more holistically account for the value streams generated by local farms, it will become easier to justify commitment of staff and funds to support the goals of successfully transitioning, protecting, and sustaining the progress made on local farms for future generations (see Table 9). Tax revenues from vacation rentals, for example, could be channeled in some percentage towards supporting farmland transitions and expanded farmworker housing, as these agricultural activities directly feed back into the tourism industry.

Table 9. Holistic Accounting Tool for Farm Value Streams

Farm Value Stream	Estimated Value (Monetary)	Additional Non-Monetary Value
Food Production	$4,245,000 (USDA 2012)	Health/nutrition
Ecosystem Services	*[Can be estimated according to payments for ecosystem service literature]*	Pasture renovation
Education	*[Payments for Farm Tours and annual education events]*	Climate education and appropriate local action
Resilience	*[Avoided payments for emergency response]*	Drought resilience through improved soil carbon storage; fire resilience through appropriate forest land management

Many farming practices used on Lopez contribute to carbon storage and thus climate mitigation, and these same practices are widely utilized due to their numerous benefits such as crop nutritional quality, water conservation and drought resilience, pollution prevention, fire resilience, improved soil fertility, and numerous positive human health and community-building impacts. However, the impacts of agroecological farming practices on sustainable economies and livelihoods is less clear, and a space for policy intervention (e.g. through job creation, county, state and federal local food procurement incentives, and state-provided social services for farmers).

On the policy side, there is a need for greater flexibility in housing allowances on lands zoned as "agricultural." This is important for both allowing farmworkers to live affordably and work on multiple farms, as well as for enabling some parcels to be farmed cooperatively, with multiple families living on and farming a piece of land. More flexibility in farmland use, ownership models, and housing availability (for both farmworkers and farm stays) has potential to serve the needs of both farmers and the agritourism industry, connecting visitors directly to the wellspring of the local food system. Legal streamlining and strategic language in county housing policy have potential to redress current farmer concerns and confusion and could expedite creative affordable housing solutions such as tiny houses for farmworker housing (e.g. with explicit language naming tiny houses as acceptable dwelling types). Several of these goals around clarifying language and allowing for ease of permitting for farm worker housing are addressed in the recent ARC memo urging the San Juan County Council to adopt section 2.2N-Agriculture as part of the Land Use Element (ARC 2019).

Adopting policies that explicitly recognize and address the need for health care, retirement funds, and basic social services among farmworker and farmer communities would further strengthen the ability of farming to present a viable, sustainable, equitable career opportunity for young and aspiring farmers. When farmers are reliant on personal wealth or off-farm jobs for benefits and financial security, the attraction and viability of farming as a career pathway is compromised. Referring back to the language of the 2011 "Growing our Future" report, state and local policies are needed to "foster farm businesses and support a thriving local farm economy." This need not be a pure market, profit-driven economy, but rather an economy that exchanges goods and services of both monetary and non-monetary value (including nutritional, physical, social, environmental, and spiritual value).

Finally, policy initiatives at the county and state level could help create fulfilling, living-wage jobs in agroecology through facilitating the relocalization of food production, processing, distribution, marketing, and education. Jobs such as 1) developing and installing appropriate technology for small farms, including on-farm energy generation, 2) preparing and distributing value-added products (for both meat and produce), 3) processing small scale grain and dry bean harvests, 4) operating an inter-island food hub, 5) processing woody debris to produce both biochar and energy, 5) tracking climate impacts and threats to agriculture at the county level, and 6) operating a climate-resilient farmer training program would help strengthen local purchasing power and keep wealth circulating within the local economy.

2.6 Conclusion: Reaching the "High-hanging fruit"

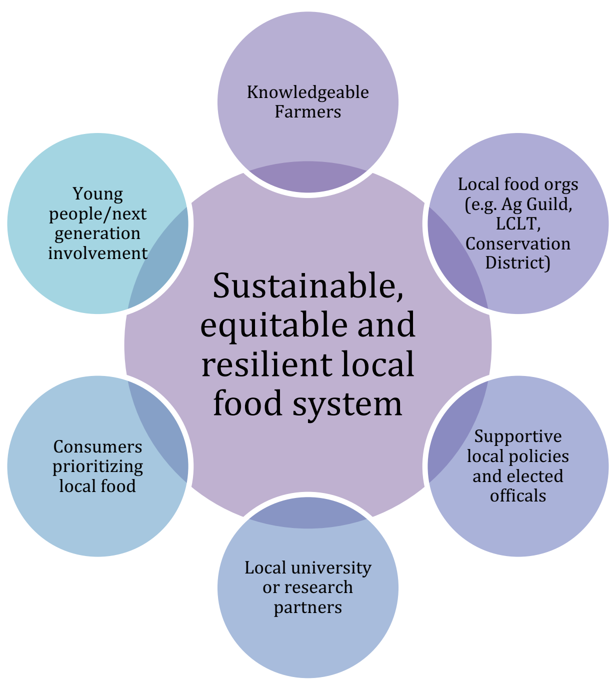

Figure 10- Elements of Building Local Food Systems

Lopez Island, and other islands in the Pacific Northwest region, are facing a pivotal moment in their pathways towards building sustainable, equitable, and resilient local food systems. Challenges are threatening progress to date, from climate change to soaring land values, to the aging farmer population without a clear pool of beginning farmers to take their place. In order to maintain progress, more investment and action is required in the policy, education, and economic arenas to level the playing field for small-scale farmers from a variety of race/class backgrounds and pave the way for socially and environmentally regenerative farmland transfers. As shown in Figure 10, many elements must be in place for building desired food systems. Lopez currently hosts a strong contingent of knowledgeable farmers, local food organizations, local university partners, and consumers prioritizing local food, while state and county agriculture policies and next generation farmer education are works in progress.

A "model" of county agriculture governance and work towards sustainable farming (for people and natural resources) on Lopez must ultimately challenge the economic roots of the dominant food system, the private property paradigm, and business-as-usual in terms of food pricing and affordability-- prices for food are too high to allow equitable access among lower income brackets, yet can't easily be reduced due to concerns of adequately compensating farmers. Therefore, addressing root causes of poverty and raising purchasing power for food among low income households is essential to restoring justice and equity in the food system. Labor considerations, living wage job availability, and affordable farmland are all challenges linked to the current political economic context. With farmers earning net negative incomes annually and struggling to access health care, these realities demand policy and political attention, reversing the trends of the "neoliberal state" placing the burden of action on individuals and directly impacted communities with limited ability to successfully confront existing corporate influence over systems of political power and food policy. Direct confrontation with existing power structures requires alliances between farmers, consumers, and policymakers. It is time to move beyond an ethic of "rugged individualism" and towards a regenerative, agroecological, and cooperative resource management ethic.

In a time of food and climate crisis, important moral, ethical, and environmental questions are raised about the current hegemony of private property ownership and a "do-it-yourself" mentality; there is a need for collective action and management of the planet's natural resources as a "commons," along the lines of Ostrom's all to action (Ostrom 2009). Conservation organizations, public land trusts, and others in the public and non-profit sphere are called upon to step into the solution space, recognizing synergistic opportunities between ecological conservation goals and sustainable food system needs. By harnessing existing resources and institutions operating on behalf of the "public good," food system goals can be met holistically, rather than focusing exclusively on one system element at a time (which is often promoted by private property and for-profit business models that channel economic activities towards specialization, either in the production space, or distribution, or retail/marketing, etc.). Society's ability to address food *system* change can be enhanced by moving outside of the private and for-profit sectors (see Bollier 2014). Furthermore, important opportunities exist in the realm of collaboration, cooperation, and collective ownership (principles behind the movement of 'commoning,') of resources in the Lopez Island food system: the Food Hub project, the expansion and coordination of Lopez Island Family Resources Center (LIFRC) activities to provide food to low-income families, and opportunities for cooperative farm management are not yet fully realized, but are among the most promising options for continued progress towards an equitable and resilient local food system. There are also promising signs of both organic and conventional farmers recognizing opportunities to come together and share information along the lines of regenerative agriculture practices, which can advance shared goals of soil preservation and enhanced crop productivity. Each of these collaboration opportunities requires some opposition to the speculative real estate market and second home industry, which if left unchecked might otherwise remove prime farmland from productive use[10].

Summarizing the work that needs to be done to secure transitions to local food systems, Judy Feldman of the Organic Farm School states, “ultimately, we need new farmers, and the question is, how to inspire more bright young people to go into growing food for us? Farming has always been complex and is growing more so due to climate change. There are complex issues in the mix: politics, regulations, food safety concerns, farmland loss. We need the best and the brightest” (Judy Feldman, Personal Interview, September 23, 2019). Echoing this climate-farming link, lecturer and farmer Eli Wheat of U.W. states, “small-scale farms can become an active part of solving the climate change problem—capturing carbon that would otherwise be stored in the atmosphere in the form of organic matter and storing it in the reserves of soil” (Leib 2018). Here, education becomes important: farmer training programs targeting both young adults, and older individuals transitioning into farming (or transitioning to regenerative practices) are in need of development to encourage the “best and the brightest” to take on the challenges of building a climate resilient and equitable food system.

From a business perspective, starting a farm is similar to starting any small business: high failure rates, steep learning curves, and a leap of faith initially, that can ultimately pay off for those who are creative and determined enough. However, the cards are stacked against small operations in today’s national political economy. There is a need to redesign policy and infrastructure to enable small farms to exist and increase their odds of success: “all of the infrastructure that used to support a diverse systems of food production has slowly disappeared in favor of larger structures presumed to be more efficient” (Wheat quoted in Leib 2018). Small scale infrastructure such as grain processing machines, mills, dry bean processing facilities, and other technologies used to be present in the San Juan Islands and must return as food systems relocalize and optimize for multiple values rather than yields and profits alone. Small farms offer many forms of value (social, ecological, educational) that large farms are often not able to, and if these values are to be held in communities, policies must shift to allow and encourage more small farms to exist.

With developments like the mobile processing unit, commercial kitchen space, and renewed interest in revitalizing a local grain economy, key infrastructure pieces are falling into place, often thanks to large private donations. In order to be transferable, the Lopez model requires further democratization and incentive alignment to allow for such infrastructure improvements in lower resourced regions. Even the relatively well-resourced and well-educated agents of change on Lopez eventually come up against entrenched political economic systems that must be revised and rehabilitated to encourage local and equitable food systems to thrive as a viable alternative to the industrial, globalized food system. Farmers and researchers working together towards goals of local production and climate mitigation often confront challenges that they alone cannot resolve. Increased dialogue and education are needed to bridge between farmer-research identified needs and the policy designs and economic restructuring needed to meet these needs. Education and training for policymakers in critical food systems challenges will be necessary to enact food system changes and “vision statements” adopted by communities through well designed policies that prevent loopholes, minimize negative unintended consequences, and embrace adaptive and evolving strategies as they emerge.

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[10] For example, the private property system is thwarting “ideal” farmland transition opportunities as farmers feel compelled to sell out to the highest bidder when they sell their land, in order to support their retirement

Islands can be natural leaders in sustainable practices, climate resilience, and local food system adoption, often out of necessity due to longer and more expensive supply chains to the mainland. Learning from the Lopez example, mobilizing a locally appropriate combination of motivated individuals, farmers educated in agroecological practices, land trusts, academics, and supportive local elected officials is a promising first step towards transforming a community food system into one that ensures food security, addresses environmental resource constraints, and mitigates climate change. Future community food systems development should be sure to bring along low income consumers and food justice organizations as active partners.

Author's Note: I had originally intended this dissertation chapter on Lopez to illustrate the San Juan Islands as a "model" of county sustainable agriculture governance and impressive progress towards sustainable food production at a community scale, rather than at the individual farm scale as is common elsewhere in regenerative small scale farming. It started off in my mind as a "case of" sustainable, small scale farming with high levels of community support. Farms on Lopez are producing an impressive amount of food through regenerative, climate friendly, non-GMO farming practices. However, progress towards a sustainable and equitable food *system* falls short of challenging the economic and political power structures underlying the dominant food system. For example, even as lots of farms are practicing regenerative agriculture and marketing directly to consumers through farmer's markets and CSA models, the farmers themselves are challenged to lead sustainable lifestyles that include making a living wage, accessing health care, finding work life balance and time for personal growth, and passing on their operations to younger farmers. The current model is not yet enabling the enthusiastic young people who serve as sustainable agriculture interns to return and take on careers as farmers. Without challenging systems like individual private property ownership, investor-controlled and profit-driven business models, national food subsidies, basic income, health care, and corporate control over branches of government, promising practices like those coming out of the Lopez farming community will not reach the ultimate goal scaling local food systems nationally that are sustainable and regenerative for farmland *and* the farmers who work those lands. Alternative examples of cooperatively owned farmland, where several farmers have a stake in the land and operations and can sell out to other like-minded individuals in a collective approach to diversified farming, are needed to provide a more regenerative culture for the farmer, not just the farmland. As Judy Feldman from the Organic Farm School on Whidbey Island puts it, we can't have regenerative agriculture without regenerative culture.

The political-economic and land tenure challenges are the "high-hanging fruit" so to speak that must be dealt with in any effort towards transformative food systems change. This chapter became a "case of" working towards holistic food systems transformation at the local, county scale, embedded within agroecological and critical food systems frames. The intertwined social, political, economic, and ecological nature of food systems transformation is recognized and expressed by the paradigm of agroecology, which is the focus of the following chapter, applied to an urban setting.

Chapter 3: Distribution: Urban Agroecology in the East Bay[11]

3.1 Introduction

Urban agriculture (UA) has sparked growing civic interest, urban farming projects, and scholarship from academic institutions across the U.S. in the past decade (McClintock, Miewald and McCann 2017; Taylor and Lovell 2012; Golden 2016; Reynolds and Cohen 2016; Santo, Yong and Palmer 2014; Hagey et al. 2012; Alkon and Agyeman 2011). There has been a proliferation of articles citing the multifaceted array of benefits attributed to urban agriculture. These span city greening and beautification to improved nutrition, public and mental health, community food security, climate change mitigation, community building, economic development and empowerment (Hagey et al. 2012; Alaimo et al. 2008; Carmody 2018; Daigger et al. 2015; Draper and Freedman 2010; Purcell and Tyman 2015). Those highlighting the beneficial environmental and ecological impacts of urban agriculture cite reduced urban heat island effect, improved local air quality, improved stormwater quality (and reduced quantity), increased pollinator populations, and climate mitigation services, such as carbon sequestration (Lovell 2010; Harrison and Winfree 2015; Kulak, Graves and Chatterton 2013). More recently, social-ecological systems (SES) scholars point out social-ecological memory developed through collective activities such as allotment gardening that can contribute to a city's resilience and are vital for governance of urban food systems (Piso et al. 2019).

Urban agriculture is often celebrated as part of the burgeoning food justice movement aimed at improving food access among low-income communities in urban areas. However, its impact on reducing food insecurity in U.S. cities remains poorly understood (McClintock, Miewald and McCann 2017; Santo, Palmer and Kim 2016). In fact, there are few robust analyses that measure the actual social, economic and health impacts of urban agriculture, or the policy and governance environments and civic engagement frameworks in which UA models are effective in reducing food insecurity. Much of the literature is theoretical, focused on the production potential of urban agriculture, while more work is needed to understand and overcome barriers to access and distribution among communities in need. Without understanding the actual links between UA and food security or which specific characteristics, models or approaches reduce insecurity, urban policymakers and advocates risk backing policies that could have unintended consequences or negative impacts on vulnerable individuals and communities.

This literature review explores the intersection between UA and food security to better understand how and to what extent UA addresses food access challenges facing low-income communities in urban areas, and the conditions that either enable or inhibit UA initiatives. The landscape of what constitutes "urban agriculture" is extremely heterogeneous: UA encompasses vertical and rooftop farming, urban foraging, community and residential gardens, and commercial urban farms. Some urban farms operate as for-profit businesses, whereas others operate as nonprofits reliant on grants, subsidies and donations to sustain their operations. For the purposes of city planning, the American Planning Association defines UA as the "production,

[11] Sections of this chapter were previously published in the journals *Sustainability* and *Journal of Agroecology and Sustainable Food Systems* with co-authors Jennifer Sowerwine and Charisma Acey (see Siegner et al. 2018 and Siegner et al. 2019). I acknowledge these co-authors' contributions and thank them for permitting me to reproduce and adapt this material as part of my dissertation.

marketing, and distribution of food and other products in metropolitan areas and at their edges, beyond what is strictly for home consumption or educational purposes" (American Planning Association 2011). In its simplest form, UA is "growing food in cities" (Taylor and Lovell 2012). We define UA broadly to encompass the full range of activities involved in urban food production including self-production and subsistence agriculture. In doing so, we follow scholars who have sought to measure the contributions of a wide range of UA activities (Golden 2016; Hagey et al. 2012; Santo, Palmer and Kim 2016).

We see three trends in current scholarship on UA in relation to community food security: (1) a focus on the production potential of urban lands, (2) case studies highlighting various nutritional, health, and other community benefits or outcomes from urban gardening initiatives, and (3) more critical analyses of UA through food justice and equity lenses. Some scholars, for example, have mapped vacant lots in Oakland (McClintock et al. 2013) and backyard gardens in Chicago (Taylor and Lovell 2012), predicting yield, to illustrate the production potential of UA. Others demonstrate, through case studies, the productivity of urban gardens and the value of the food they produce in meeting nutritional needs of low-income communities, particularly households involved in gardening directly (Algert et al. 2014; Altieri et al. 2016; Allen 2008; Armstrong 2000; Blair et al. 1991). Robust theoretical analyses have emerged critiquing the risks of UA when approached without an equity lens, potentially reinforcing structural injustices and racism and negatively impacting the communities they purportedly serve (see Alkon and Guthman 2017 and McClintock 2014 for specific examples of critiques of the hidden neoliberal ideology of urban food movements).

Deeper historical and structural challenges including poverty, racism, and divestment in specific communities and neighborhoods are increasingly being recognized as the root causes of the current problem of unequal access to sufficient supplies of safe, nutritious, affordable, and culturally acceptable food facing cities (McClintock, Miewald and McCann 2017; McClintock 2018; McClintock 2011). Designating land for agricultural use in urban areas may conflict with other city planning priorities around affordable housing, gentrification, and living. Because of the persistent legacy of systemic discrimination, it is neither inevitable nor guaranteed that urban agriculture will redress food system inequities; in fact, urban farms can sometimes lead to displacement through eco-gentrification (McClintock 2018; Anguelovski 2016; Cohen 2018; Voicu and Been 2008; Whittle et al. 2015). This is a particularly acute concern in areas experiencing housing pressures and population growth, such as the San Francisco Bay area and New York City. UA can also perpetuate positions of privilege within the food system by benefiting those who already hold power (McClintock, Miewald and McCann 2017). Critical food systems scholars question, "who really benefits, and who loses in specific efforts to promote urban farms in the 'sustainable city' landscape?" (Alkon and Guthman 2017; Horst et al. 2017; Ramirez 2014) and, "how can white food activists reframe their work so as not to fuel displacement of residents of color?" (Ramirez 2014).

We examine the role of urban agriculture in addressing food insecurity from a systems perspective, one that considers the policies and institutions that govern the process in which food is produced, processed, distributed and consumed, in order to ask four central questions: (1) How and to what extent are urban produced foods reaching low income consumers, and to what effect? (2) What are the approaches, technologies, institutions and relationships that support or detract from UA in achieving food security goals? (3) What are the political, institutional, cultural, historical, and civic action conditions that enable or inhibit urban agriculture to address food insecurity? Lastly, (4) How can policies be designed to support the urban farmer in earning a living wage, *and* support low-income consumers in accessing affordable, locally produced healthy foods?

We begin by describing our literature review methodology, followed by a review of the food access and food distribution literatures as they relate to the question of how low-income communities access urban produced food. In the food access literature, we review spatial analyses and other studies that identify challenges and opportunities for expanding healthy food access in low-income communities, with a particular focus on urban produced foods. Next, we explore what is understood about the distribution of urban-produced foods especially the challenges and tradeoffs urban farmers face between securing a viable income and meeting the food needs of low-income customers. Lastly, we bring together the literatures on access to and distribution of urban produced foods to identify effective strategies urban farms employ to meet food access needs of urban communities. Our analysis reveals three key factors mediating the effect of UA on food security: the economic realities of achieving an economically viable urban farm, the role of city policy and planning, and the importance of civic engagement in the urban food system. We seek to highlight examples from both the scholarly and gray literatures that demonstrate how UA can improve food access, distribution, and justice, in a way that supports both consumers and producers of food in cities.

Results of this systematic review will guide a three-year research project to investigate and address urban food access challenges in the eastern region of the San Francisco Bay Area, where interest in UA abounds, yet levels of gentrification, food insecurity, and income inequality are growing.

3.2 Materials and Methods

Our systematic review of the food access and distribution literature builds on critical food systems research in order to better understand when, where and how urban agriculture can improve food access and dismantle structures that perpetuate inequality within the larger food system. We focus on literature from the United States, in order to generate ideas relevant to the political climate surrounding city and regional planners in this country, but results are applicable for comparison or potential transferability in other countries as well. We consider both peer reviewed scholarship and gray literature from food policy organizations (i.e., Johns Hopkins Center for a Livable Future, PolicyLink, City University of New York (CUNY) Urban Food Policy Institute, Detroit Food Policy Council, and Race Forward). Both theoretical scholarship and case studies are drawn out below to illustrate the question of whether UA improves food access (and if so, how?).

Building on a set of 150 articles from the researchers' personal databases (based on research careers in Cooperative Extension, Local Food Systems and Urban Planning), we added an additional 200 sources from five months of Google Alerts for "urban agriculture" and from bibliographies of articles in the database. The Google Alerts (screened for relevance to this review) provided valuable additions from new studies, local news outlets, and gray literature. In many ways, the Google Alerts service better captures current trends and innovative ideas in urban agriculture than the scholarly literature, and points out important areas for future academic study, especially with respect to novel distribution methods, technology, and food recovery efforts. For example, topics such as mobile food trucks, gleaning, "agrihood" developments, participatory urban food forest projects, online food exchanges (e.g., CropMobster), and food distribution apps receive better coverage in local news outlets than the current body of peer-reviewed literature, where these emerging ideas are largely absent. Many of the online platforms that allow farmers and backyard gardeners to sell, donate, or receive volunteer harvest assistance represent especially promising areas for future scholarly research (e.g., The Urban Farmers, Ample Harvest, or Seed Voyage). Farmers, Ample Harvest, or Seed Voyage).

We used this body of literature to generate a list of key terms for several Web of Science searches to systematically identify the peer-reviewed literature from 1900 to present. The dataset construction and selection criteria are summarized in Figure 11.

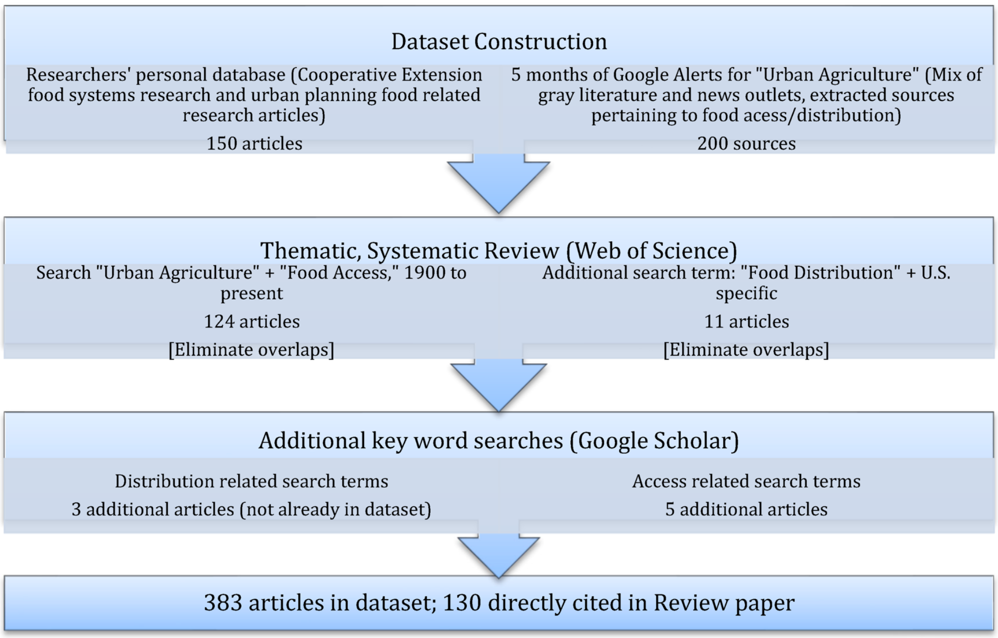

Figure 11- Selection Criteria Flow Chart

Other searches for key terms relating to food access including “food justice”, “food security”, “food sovereignty”, “food apartheid”, and “critical food geographies” added small numbers of articles to our systematic review. Terms were chosen based off keyword lists from articles in the database and results were screened for geographic relevance (U.S.) and mention of urban produced foods. These terms and search results bring up important questions of who prefers and uses which terms, and why. The struggle over terminology mirrors broader struggles for control, power, and self-determination. Going beyond ‘food security’, the term “food sovereignty” originates from La Via Campesina and the predominantly rural small producers movement in the 1990s; it is applied to the urban space by scholars such as Alkon and Mares (2012) and Block et al. (2012) as a distinctly political concept that is “a transformative process . . . to recreate the democratic realm and regenerate a diversity of autonomous food systems based on equity, social justice, and ecological sustainability” (Block et al. 2012). Those who use “food apartheid” aim to directly implicate the segregation that is reproduced in the modern food system and food movements with respect to who can access healthy, locally produced food along racial lines (Bradley and Galt 2014). These scholars foreground issues of race in their analyses in effort to name and dismantle racist legacies in the food system.

To identify the body of literature pertaining to the distribution of urban-produced foods, it was necessary to expand our search terms beyond “urban agriculture” and “food distribution”, and start with “food systems”, “distribution”, and “urban” as key search terms. We then filtered the results of this search to exclude articles pertaining solely to location of supermarkets in food deserts, a common area of research but not the focus of this study (we are particularly interested in the distribution of urban produced foods, rather than produce from most supermarkets). We also conducted searches for "urban foodshed" (a term introduced by permaculturist Arthur Getz in the 1990s; see Kloppenburg et al. 1996 and Peters et al. 2009), "alternative food networks", "informal food distribution" and "short food supply chains", (a term more commonly used in Europe) in order to track down missing literature from our collection investigating the transfers of food produced in cities. This iterative search process on the distribution side reveals the difficulties in tracking informal food distribution networks, but also the importance of doing so to better understand the real impact of urban agriculture on food insecurity in cities.

Data analysis comprised content analysis of article abstracts to identify key findings among the case studies considered, and closer reading of other review articles to identify trends and gaps in the literature. Themes were extracted from articles considered, and grouped by study type (e.g., case study, review, theoretical analysis) to determine which types of studies provide which data.

3.3 Food Access: Do Low-Income Urban Consumers Access Urban Produced Foods?

Community food security is defined by the Community Food Security Coalition (CFSC) as "all persons obtaining at all times a culturally acceptable, nutritionally adequate diet through local non-emergency sources", with urban agriculture playing an important but integrated role in this effort. According to Horst et al. (2017), expanding urban agriculture operations across cities "does not guarantee that people experiencing food insecurity will access that food…Distribution and access matter." Food access, closely related to the term food security, constitutes the process of obtaining certain foods (in this case urban-produced) and includes educational, cultural, geographic, and economic dimensions.

The literature on fresh food access in low-income communities often focuses on food desert analyses studying lack of grocery stores; however, focusing on "lack of stores" does not address historical underinvestment patterns and underlying structural causes of food insecurity and oversimplifies the solutions landscape (McClintock 2011; Handbury et al. 2015; Cummins and Macintrye 2002; Bedore 2010; Galvez et al. 2008). Other literature studies efforts to bring in fresh food through farmers markets locating in underserved communities, or through offering fresh produce (not necessarily urban produced) in corner stores (Larsen and Gilliland 2009; Wang et al. 2014; Sadler 2016). Both efforts have met with limited success (Gudzune et al. 2015; Lucan et al. 2015; Misyak et al. 2014). Less is known about the actual consumption of urban produced foods by low-income communities. When certain literature reviews (e.g., Golden 2016; Hagey et al. 2012) claim that urban agriculture improves food access among food insecure households and communities, it is often from a productivist conceptualization of "access." This productivist focus in the literature conflates existence of urban farms (and thus increase in urban food supply) with increased access, without examining where the food actually goes and who consumes it.

As critical food scholarship points out, "the focus of food access as an issue goes beyond the particular connections to health (although these are important) to be a way that issues of power, control, and inequality are written into the American landscape" (Block et al. 2012). Below we outline barriers to accessing urban produced foods, including physical proximity, cost of food, cost of land, cultural acceptability, and nutrition education, identified from an interdisciplinary body of literature spanning urban agroecology, public health, development economics and food geography. We then describe several successful examples of UA increasing food access, drawing on food sovereignty perspectives. This body of literature stands to benefit from more robust data on actual consumption of urban produced foods, requiring innovative data collection methods and household observations to determine if access (obtaining food) and consumption (eating it) are in fact closely matched.

3.3.1. Spatial Analyses Highlight Productive Potential and Uneven Distribution of UA

In land scarce cities striving for “best and highest use” of each lot, food production in small spaces is often considered insufficient (or inefficient) for meeting the needs of food insecure households. To address those critics, the localized food systems scholarship offers a fair amount in the landscape ecology and planning literature theorizing the high productive potential of UA to address food insecurity (Taylor and Lovell 2012; McClintock and Cooper 2010; Clinton et al. 2018; Galzki et al. 2014). Spatial analyses such as those cited above provide insights into theoretical access, while not addressing the policy, governance and practical barriers that would need to be overcome in order to realize the potential of so many vacant lots as productive food growing spaces.

There is value in spatial analyses such as these, as they offer optimal siting locations and productivity quantifications that are useful targets for planners, practitioners, and evaluators seeking to verify or ground truth theoretical projections. The optimal siting analyses, using census block group data, promote food justice by prioritizing low-income communities when siting urban farms in effort to increase access (Parece et al. 2017; Mack, Tong and Credit 2017). From a global quantitative mapping analysis done with Google Earth Engine, urban agriculture was found to “positively influence food production, nitrogen fixation, energy savings, pollination, climate regulation, soil formation, and the biological control of pests, services that are worth, as a whole, as much as $160 billion” (Clinton et al. 2018). This study suggests the ability of urban agriculture to improve food security on a global scale (acknowledging significant country-to-country variability).

Other theoretical mapping analyses have also found that urban and peri-urban farms can supply significant amounts of food demand in urban centers: from 5–10% of city vegetable demand supplied by expanded UA on public lands in Oakland (McClintock and Cooper 2010) to 30% of seasonal vegetable demand in Detroit (Colasanti and Hamm 2010), to 100% of nutritional needs in Southeastern Minnesota (Galzki et al. 2014). However, very few studies directly quantify how much urban produced food is actually being consumed by low-income food insecure communities, requiring observational and qualitative research methods. Furthermore, these and other studies focus strictly on the productive capacity of UA, while there is much more being produced by UA than food alone (community empowerment, educated food consumers, city green space, etc.), and the products of UA may not perfectly align with existing consumer taste and food purchasing behaviors, requiring dietary shifts that are not yet occurring (Manskar 2018).

What is the spatial reality of food access on the ground? A mapping analysis of Chicago by Taylor and Lovell (2012) finds access to urban agriculture and urban-produced foods to be unevenly distributed, and household gardens correlate spatially with patterns of gentrification in Portland (McClintock et al. 2016). In Taylor and Lovell’s analysis, they attempt to quantify production and spatial area of urban agriculture using both manual interpretation of high-resolution images and ground-truthing data from walking the city. They find production from residential gardens to be a threefold increase in food production over community gardens, and find both home and community gardens to be highly unevenly distributed: most home gardens are in Chinese and single-family-home neighborhoods, and most community gardens are in the south and west side due to higher land availability, meaning many urban core, low-income census tracts lack access to community or residential gardens. They advocate for better networking of community garden sites to increase access, strategic location of future community gardens among neighborhoods in need, and an emphasis on creating and encouraging home gardens as a key food production strategy available to many city residents. Mack et al. (2017) find that 68 urban gardens in Phoenix, AZ are currently serving just 8.4% of "food desert" residents, and through spatial analysis, 53 gardens sited strategically could serve 96.4% of such residents. From these studies, it is clear that UA projects are not necessarily occurring where they are most needed to increase food security.

When it comes to spatial analyses, "while a macro-level quantitative study of the potential in terms of land availability shows that it would be feasible to grow the basic daily vegetable needs for the urban poor in the United States, current evidence from urban farms located within lower-income communities shows that such farms are not necessarily feeding the communities in which they are located," due to a variety of factors including cost of produce and cultural desirability (Santo, Palmer and Kim 2016). The sections below address these other factors influencing access.

3.3.2. Cost of Urban Produced Foods

Barriers to access are not just due to geographic distance, but rather an array of intersecting factors including the high costs of some urban produced foods, especially from commercial or for-profit operations. Fresh, local produce from vertical or rooftop farms such as Gotham Greens (NYC), Plenty (San Francisco) Higher Ground Farm (Boston), Freight Farms or AeroFarms (various locations) are often sold at a premium to restaurants and grocery stores, and thus unaffordable to low income households (Holt 2018). Despite claims that vertical farms can "feed the world in the 21st century" (Despommier 2010), it remains to be seen if vertical farms can address food access and food justice. Such farms are often following a corporate food system model of profit maximization and resource use efficiency, subscribing to capitalist logics rather than alternative, social-justice-oriented practices. Among for-profit farms, "the few profitable operations tend to be those selling to high-end restaurants and consumers, not to lower-income residents" (Santo, Palmer and Kim 2016).

The cost of food, especially healthy fresh produce, is often in tension with other high costs of living in urban areas (including housing and healthcare), causing low-income residents to become dependent on emergency food services and food pantries. This intersects with poor nutrition and diet-related diseases- according to the Alameda County Community Food Bank Hunger Study report, "food is often the most critical factor in our clients' health", and 40% of clients are in fair or poor health (ACCFB 2014). Food banks and food pantries fill important "access gaps" that urban farms could better supplement or address if cost of urban produced food was made more affordable, or through donations to food banks (food banks often cite fresh fruits and vegetables as particularly needed donations; ACCFB 2014).

Low-income households can circumvent the high costs of urban produced food from commercial farms by establishing their own backyard gardens (if possible), or adopting plots in community gardens. Through direct participation in UA, in particular (whether volunteering on urban farms or adopting plots in community gardens) food insecure individuals can offset significant percentages of fresh vegetable expenditures , and enhance food security through improved healthy food access (Alaimo et al. 2008; Kortright and Wakefield 2011; Gray et al. 2014; Algert et al. 2016; Saldiva-tanaka and Krasny 2004). Access via UA participation is certainly enabled when urban farms and gardens are physically proximate to low income neighborhoods, demonstrating the intersection of cost and geography in expanding access.

There are abundant examples of non-profit farms that give food away for free or at reduced rates (e.g., Urban Adamah, City Slicker Farms, U.C. Gill Tract Farm, and Mills College farm in the Bay Area), yet there is little scholarship on the consumption or impact of donations/discounted offerings specifically.

3.3.3. Cost of Land and Labor

High costs of land and development pressures also play a significant role in limiting access to both farming and locally-produced foods, as seen in studies of Chicago, New York City, and the San Francisco Bay Area (Taylor and Lovell 2012; Smith and Kurtz 2003; Schmelzkopf 2002; Reynolds 2015; McClintock, Cooper and Khandeshi 2016). High cost of land prevents community gardens from being established in the urban core in Chicago, leads to hundreds of community gardens in NYC slated for redevelopment annually, and drives gentrification and displacement in neighborhoods around urban farms. Land tenure insecurity directly contributes to lack of access as many urban farms formerly serving minority and immigrant populations have been forcibly closed due to development priorities for privately owned lots (i.e., La Finquita in Philadelphia, PA; South Central Farm serving predominantly Latino households in L.A.; Free Farm in San Francisco; Brooklyn Community Farm in NYC). A recent article on land security indicators among California urban farmers showed that farms with higher land security also had “more financial and institutional support, and are located in census tracts with higher economic opportunity” (Arnold and Roge 2018). This highlights the necessity of devoting publicly owned lands to urban agriculture in low income and minority neighborhoods, as private lands are highly vulnerable to development pressures, thus jeopardizing any gains realized by social justice oriented urban farms.

In contexts where urban farms strive to provide living wage jobs and career or educational opportunities for low-income communities, youth, or formerly incarcerated individuals, it is often challenging to also provide food access to these same communities. Unless significant grant funding or donations exist, the goals of boosting food security are in tension with capitalist economic realities to pay living wages and sell the product (urban produced foods) at below-market costs (Daftary-Steel, Herrera and Porter 2015; Biewener 2016). This speaks to the “unattainable trifecta of urban agriculture,” that is the idea that UA can simultaneously achieve community food security, provide on-the job training and fair living wages, and generate revenue through sales to cover these costs without substantial outside investment (Daftary-Steel, Herrera and Porter 2015), as well as the tension between farm security and food security (Allen 2004; Guthman, Morris and Allen 2009). In examples such as City Growers and Higher Ground Farms in Boston, organizational efforts to provide jobs and job training lead to marketing of produce to high-end restaurants, retail establishments, farmers markets, and CSAs at prices unaffordable to food insecure households (Bradley and Galt 2014; Biewener 2016).

3.3.4. Culture, Education, and Innovative Urban Food Sources

A fourth important food access barrier cited in the literature relates to cultural acceptability and nutrition education, widely accepted as part of food security definitions (Santo, Palmer and Kim 2016; Alkon and Mares 2012; Bradley and Galt 2014). Access to culturally appropriate foods is known to be an important factor (Santo, Palmer and Kim 2016; Kato 2016; Beckie and Bogdan 2010), yet little is understood about the effects of urban farms growing culturally relevant foods and its relation to food access. More qualitative research is needed on the cultural acceptability of urban produced foods and how that might correlate with improvements in access. There is increasing evidence of the importance of culturally relevant educational materials (in multiple languages) around nutrition, food literacy, and culinary skills for improving access and actual consumption of healthy, fresh, urban-produced foods among low income, minority, or immigrant households (Kato 2016; Cummins et al. 2014; Rodier, Durif and Ertz 2017). Culinary skills and food literacy are becoming focal points of school garden programs (National Farm to School Network), and innovative organizations such as the Green Bronx Machine show how urban agriculture embedded into high-needs schools can directly improve food education, which translates into increased access and consumption (Green Bronx Machine 2018). Additional research is needed to quantify the impact of educational school gardens on community food security.

Recent urban foraging literature is exploring stewardship practices and culturally relevant products (both food and medicine) gathered by foragers in cities around the world, as well as the sociocultural benefits that result (Poe et al. 2016; McLain et al. 2017; Shackleton et al. 2017). From Mien immigrants gathering dandelion bud-shoots in urban parks (Kell 2018), to informal urban foragers helping maintain trees and parks in Seattle, WA ranging in age from 23 to 83 (Poe et al. 2016), to the value of edible weeds (Stark and Carlson 2018) urban foraging is an activity that recognizes certain agroecosystems as "commons" for public access and management. Urban forest justice scholars "recognize the rights of local people to have control over their own culturally appropriate wild food and health systems, including access to natural resources and to the decision-making processes affecting them" (Poe et al. 2016). The potential to address food insecurity with foraging and gleaning activities is being explored by organizations such as Ample Harvest (national) and The Urban Farmers in Northern California; Ample Harvest's online platform supports over 42 million backyard and community gardeners in ending food waste by channeling excess produce to 1 out of every 4 food banks across the country (Ample Harvest 2018).

While some food justice scholars conclude that current shifts toward local, organic, sustainably produced foods are only accessible and affordable to those with higher economic means "or at least the cultural cachet necessary to obtain such foods through barter, trade, or other means of exchange" (Alkon and Agyeman 2011), the examples above illustrate successful alliances of food justice advocates and local government working to enable sustainable, healthy food access for all urban residents. Through strategic planning and policy design, it may be possible to move beyond ad-hoc successes in linking urban agriculture with food access. The articles reviewed in this section provide a mix of academic studies, theoretical arguments, and policy literature. Additional empirical evidence and longitudinal studies are needed to demonstrate the ability of UA to significantly improve nutrition and food insecurity among urban low-income households over time. Furthermore, consumer preference surveys of urban produced foods are a conspicuous absence in the reviewed access literature. We turn next to food distribution, and the question of how urban produced foods get from the farm to the consumer through various distribution mechanisms.

3.4 Food Distribution: How Do Urban Farmers Get Their Produce to The Consumer?

What does the literature tell us about the distribution of urban produced foods? While many articles reviewed mechanisms for channeling rural or peri-urban produced foods into urban areas to increase fresh produce access (e.g., farmers markets, CSAs, direct purchase agreements), very little scholarly data exists on the distribution and accessibility of urban produced foods, and what does exist is largely under-theorized. In fact, very few sources reviewed explicitly name “food distribution” as a key term. Urban agriculture remains a relatively small, yet important percentage of the larger food distribution system in cities: “few, if any, urban agriculture projects, are intended to replace traditional food retail or would claim to lead to food self-sufficiency for individuals or for cities” (Santo, Palmer and Kim 2016). As such, very little is understood about where and how urban farmers distribute their food including modes of transportation delivery, either individually or in aggregate, and to whom (retail, institution, anti-hunger programs). It is important to focus on the means through which food produced by different types of farm operations travels from farm to consumer, and the processes through which that food is exchanged (both monetary and nonmonetary), as this directly impacts access and consumption. The scholarly literature as well as media stories describe various modes by which fresh produce is distributed in the city to address fresh food access including both formal (CSA, farm to institution, farm stand, farm to retail, farmers’ market) and informal distribution channels (crop swaps, mobile food markets, online food hubs, volunteers taking food home, household production) (Bradley and Galt 2014; Daftary-Steel, Herrera and Porter 2015; Biewener 2016; McCracken, Sage and Sage 2012; Satterfield 2018).

Applying a distribution lens to the existing literature yields similar results to the food access analysis in that several articles theorize idealized distribution systems, showing the capacity of hypothetical urban and peri-urban farms to supply distribution networks that meet most urban food demands (Peters et al. 2009; Clinton et al. 2018; Galzki et al. 2014; Parece et al. 2017; Mack, Tong and Credit 2017; Colasanti and Hamm 2010). Others highlight barriers and challenges farmers face in practice around distributing their produce to those in need while maintaining their operations (Daftary-Steel, Herrera and Porter 2016; Biewener 2016). None, in our search, focus analysis on distribution flows of urban produced foods across a city. Rather, a more common focus is on which distribution channels are best for getting produce, not necessarily urban produced, into the hands of food insecure households or residents of “food deserts” (McCracken, Sage and Sage 2012; Short, Guthman and Raskin 2007). Is it a corner store, a large supermarket, or small local farm stand within a mile radius that households need to access fresh produce?

3.4.1. Distribution via Corner Stores and Supermarkets

In the case of corner stores, several studies have built on analyses of the prevalence of corner stores and liquor stores in low-income census tracts (juxtaposed with the absence of large supermarkets) and endeavored to study the effects of providing fresh local produce in these stores otherwise carrying largely processed foods and sugary beverages. Results have been mixed, with some cases of pairing urban farms with corner store retailers yielding increases in sales of fresh produce (Gudzune et al. 2015), but others showing no increase and even resistance from corner store operators who feel that this produce will not sell and therefore become a waste disposal issue (Gudzune et al. 2015; City of Richmond; HOPE Collaborative 2008). Small neighborhood groceries and mobile markets were found to be promising distribution outlets for expanding access to fresh produce in some Oakland, San Francisco, Erie County NY, and New Orleans communities (Short et al. 2007; Satterfield 2018; Raja et al. 2008; Zepeda et al. 2014; Bodor et al. 2008; Bolen and Hecht 2003). However, they are unevenly distributed and conflicting in terms of providing culturally appropriate foods to all minority groups (see Short et al. 2007). In most cases, (a) additional trust and consumer education as well as (b) lower costs and better infrastructure (e.g., refrigeration space) are needed in order to make small groceries and corner stores reliable, accessible, affordable, and sustainable in their operations over the long term.

Supermarket access studies demonstrate mixed results on whether providing a supermarket alone is sufficient to resolve problems of "food deserts"; in fact, supermarkets can contribute to displacement through "supermarket greenlining" (Anguelovski 2016; Handbury et al. 2015; Galvez et al. 2008; Gatrell et al. 2011; Unger and Wooten 2006). Critical scholarship in the food desert literature finds that revealing food access inequities "often leads to a public response that focuses on only food stores themselves [or creation of new sites for market transactions], rather than a broader focus upon the inequities in economic investment, political and economic power, and health that the food desert issue highlights" (Block et al. 2012).

3.4.2. Distribution via Farmers Markets

Farmers markets as distribution sites receive critical assessments in the literature for their ability to serve as distribution channels to low-income consumers. Alison Hope Alkon writes about the closing of a farmers' market in West Oakland, a historically African American neighborhood, juxtaposed with the white spaces of farmers markets that are thriving in neighboring Berkeley in her book Black, White and Green: Farmers Markets, Race and the Green Economy (Alkon 2012). She theorizes the promise and limitations of the "green economy" and chronicles the food movement's anti-capitalist roots yet ultimate manifestation as reproducing capitalist inequalities. Lucan et al.'s study of farmers markets in the Bronx took issue with limited hours of operation, seasonality, affordable common produce, and availability of predominantly healthy foods among farmers markets (Cohen 2018) compared to nearby stores (Sadler 2016; Lucan et al. 2015). Accepting Electronic Benefit Transfer (EBT, or Food Stamps) payments is a basic prerequisite for farmers markets to be considered accessible to low-income consumers, a concept pioneered by the GrowNYC's Greenmarket program (NYC Food Policy Center 2018). While farmers markets in all 50 states now accept food stamps (3200 markets and counting), the price of offerings such as a bunch of kale still exceeds the price of nearby fast food options that may offer a more filling but less nutritious meal option. Some states (including Oregon, Massachusetts, Michigan, California, Washington, Illinois and New York) are moving in the direction of matching EBT funds through various "market match" policies, a step towards improving food distribution and access at farmers markets (Snap to Health 2018).

3.4.3. Theorizing the Distribution "Foodshed" via Alternative Distribution Channels

The concept of a foodshed in the distribution literature, "like its analogue the watershed, can serve as a conceptual and methodological unit of analysis that provides a frame for action" (Chen 2012). Foodshed analysis "provides a way to assess the capacity of regions to feed themselves" through proximate location of food production, distribution and consumption (Horst and Gaolach 2015). Applying this concept, Peters et al. (2009) found that 34% of New York State's total food needs could be met within an average distance of 49 miles, (data skewed by

New York City, which depends upon procuring foods from greater distances; most areas of the state were able to rely completely on in-state production). The foodshed, embedded in the local food systems and short food supply chain concepts, is a useful organizing principle for city planners to consider when designing effective food distribution networks, such as the example highlighted in (Chen 2012) integrating a farm into a housing development project in the South under the title of a "civic agriculture community," facilitating proximate, affordable distribution channels. This exemplifies planning with a foodshed lens by specifying areas at the neighborhood scale for semi-commercial agriculture, neighborhood CSA, residential kitchen gardens, and residential development in order to build food access and ease of distribution into the neighborhood fabric.

If urban farmers aren't able to easily distribute their produce to consumers, either through sales or other forms of distribution, questions of improving food access are jeopardized as well, revealing the interconnectedness of the food systems framework from production to distribution to consumption. Planning for improved urban food distribution includes ideas such as food hubs, agri-hood developments, public storage and transportation options, food aggregating facilities or organizations, mobile food distribution, or state investment in public markets (Pensado-Leglise and Smolski 2017; Cooper 2018; Wallace 2017; Widener et al. 2012). Mobile food distribution options are modeled and shown to increase access in Buffalo, NY, in Widener et al.'s theoretical analysis (2012). Agri-hoods have gained increasing mention in local news outlets as a real estate trend in "Development Supported Agriculture (DSA), and as many as 200 currently exist or are under construction across the country" (Wallace 2017). They facilitate distribution by co-locating food producers and consumers on strategically planned sites, providing shared infrastructure resources, and making land access affordable for farmers by cross-subsidizing with real estate development. Cooper's report on food hubs in the south, a form of aggregating supply to enable expanded market access, highlights grassroots solutions developed by and for farmers of color, yet "major challenges [remain] associated with developing and maintaining food hubs within a racial equity framework" (Cooper 2018).

Here again, the Google Alerts provide useful insights from gray literature and local news outlets into recent and effective strategies for city planners, be it food hubs, mobile food distribution options, online platforms for gleaning, second harvest, crop swaps, or distributing excess produce from backyard gardens. These are also areas that stand to benefit from additional scholarly research in terms of quantifying impact on consumption, food insecurity, and nutrition, expanding evaluations of urban food systems to include nonmonetary and informal distribution mechanisms.

Integrating the access and distribution literature from above, we identified three themes that speak to the efficacy of urban agriculture in meeting food access goals: economic viability, policy and planning models, and civic engagement.

3.5 Access and Distribution

3.5.1 Economic Viability

In this section, we consider the economics of urban agriculture and the "economic marginalization" (Weis 2007) that prevents many operations from meeting all the social and environmental benefits of urban agriculture within a for-profit or capitalist-oriented production scheme. The urban food justice and food sovereignty movements in the U.S. are limited in practice in achieving their more radical or transformative goals due to the fact that they are operating within "a broader framework of [capitalist] market neoliberalism" (Clendenning et al. 2016). The challenge has not been growing enough food per se, but rather "producing and distributing food in ways accessible and affordable for the growing urban poor" (ibid.) while sustaining UA operations in a capitalist, production- and profit-oriented society.

Daftary-Steel, Herrera and Porter (2015) declare that an urban farm cannot simultaneously (1) provide jobs to vulnerable individuals, (2) provide healthy food to low-income households and (3) generate sustainable income and/or profits from sales. Therefore, what forms of urban agriculture are economically viable in today's political economy? Operations that provide jobs, job training and professional development but sell mostly to high-end consumers (e.g., Planting Justice, Homeless Garden Project, Dig Deep Farms, City Growers), operations that are volunteer-driven or publicly funded (New York City's GreenThumb program or Berkeley Community Gardening Collaborative) and operations that cross-subsidize healthy food donations with revenues generated from other services besides food production (primarily educational) or from crowd-sourced funding (e.g., The Food Project, Urban Adamah, Food Shift Kitchen, Planting Justice).

When it comes to economic viability, many urban farming operations openly acknowledge that they are dependent on grants and donations to sustain their operations, which is a double-edged sword. On the one hand, as long as an organization can prove itself worthy (and therefore achieve success) in receiving grants and donations, it may represent economic viability and long-term sustainability. On the other, if the organization is wrapped up in a charismatic individual leader or fails to receive ongoing grant injections beyond one or two initial successes, it will not achieve long-term economic viability.

Alternative economic models are emerging and require further study. Examples include redistributive business models, barter and exchange networks, food aggregators, food recovery organizations, cooperatives, food hubs, and "agrihoods" (Biewener 2016; Cooper 2018; Doherty 2018). Food hubs are reframed as both tools for provision of market access (enabling economic viability) and self-determination for black farm cooperatives in the South in Cooper's report (2018) with potential to subvert historic racism and economic marginalization of black farmers. Key to this and other food policy reports in the gray literature is elevating voices and fostering dialogue led by communities of color.

3.5.2. Policy and Planning Models

While food, and urban agriculture, used to be "strangers to the planning field" (Pothukuchi and Kaufman 2000) or "puzzling omissions" from American Planning Association resources prior to the early 2000s (Morgan 2009), there has been an increase in academic work in the past 10 years dealing with urban food systems planning. In this section we consider the policy landscape of various city and state efforts to incentivize and create space for urban agriculture. Policy is needed to (1) lower costs for low income consumers and urban farmers seeking land, (2) provide strategic location of distribution sites, and (3) encourage year-round produce supply, often enabled by greenhouse systems in urban farms.

Are current policy incentives enough to create expanded food access and community food security from urban farms? Horst et al. (2017) would argue no; rather, an explicit commitment to food justice and an "equity lens" is needed for policymakers and planners to create UA spaces that benefit low income and minority communities equally if not more than already advantaged groups. Due to the current landscape of "disparities in representation, leadership and funding, and insecure land tenure," unless these problems are explicitly addressed, "even the most well-intentioned initiatives will perpetuate or even reinforce the injustices that practitioners and supporters aim to address" (Horst et al. 2017). This sentiment is echoed in Morales' chapter in *Cultivating Food Justice*, which calls for "applied research to discover and advance *policy objectives* related to the antiracist and economic objectives espoused by the Growing Food and Justice Initiative" (Morales 2011). This suggests that only by foregrounding issues of race and economic inequality can cities create UA spaces that address food insecurity.

In asking the question "Can cities become self-reliant in food?" Grewal and Grewal (2012) find that, in a best-case scenario, the City of Cleveland *can* achieve almost 100% self-reliance in fresh produce needs, poultry and eggs, and honey, but only with huge amounts of planning support (to devote necessary commercial rooftop space as well as vacant lots to food production). Blum-evitts puts forth a foodshed assessment tool to allow planners to assess local farm capacity in relation to local food needs (Blum-evitts 2009). Theoretical work such as this is important to advance ideas of what is possible and motivate efforts to make change, although it must constantly stay in dialogue with what is happening in practice and expand beyond a productivist focus on local food systems. Urban farms are, after all, producing a lot more than food, and "increasing food production in cities does not guarantee that people experiencing food insecurity will access that food" (Horst et al. 2017). UA is re-valued along a broader spectrum of "products" or outputs in Figure 12 below.

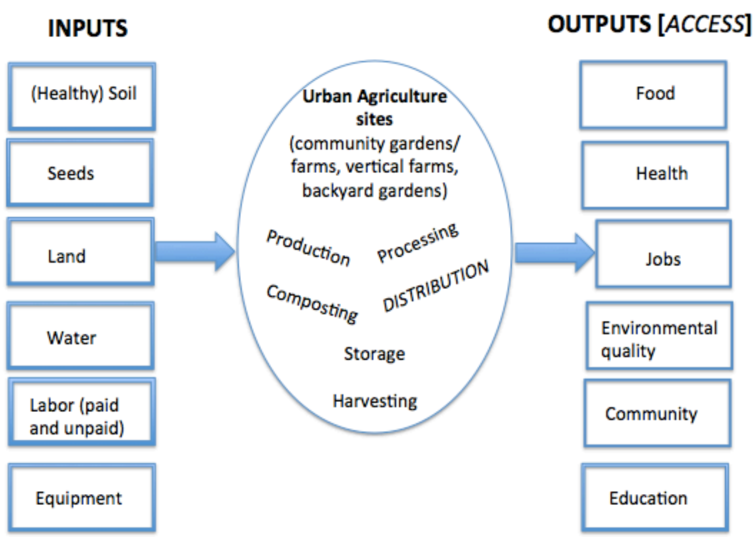

Figure 12- Multiple Inputs and Outputs of Urban Agriculture

Creating urban agriculture incentive zones is one possible approach to policy and planning, likely to benefit the propertied class via tax breaks (Havens and Alcala 2016). Policies such as California's AB 551, the Urban Agriculture Incentive Zone act, have come under criticism for not going far enough to build a just food system, relying on private rather than public spaces to support UA. It is unclear whether incentive zones will be widely adopted by cities and counties in California, and whether they will meaningfully address food access or food sovereignty, especially when the length of time required to devote a piece of land to urban agriculture is only 5 years. In cases where tax incentives are used to promote urban agriculture, primary beneficiaries of the policy are often the privileged class of property owners rather than low-income households or non-property-owning urban farmers.

Cities with some sort of food policy regulating, allowing for or promoting urban agriculture include the City of Baltimore (2013), City of Somerville, Detroit, Portland, Madison, Seattle, San Francisco, San Jose, Los Angeles, San Diego, Austin, Minneapolis, New Orleans, Milwaukee, Boston, and Chicago[12]. Many policies allow for commercial sales of urban-produced food within the city as "approved sources" (food can be sold or donated, e.g. California Community Food Producer Act, 2014); allow for value-added processing and sale of urban produced foods in people's home kitchens (bringing an important revenue generation option to many low-income urban farmers; e.g., California Cottage Food Act); create tax incentives for property owners to convert land into urban farms (e.g., California Urban Agriculture Incentive Zones); amend zoning regulations (e.g., Chicago Urban Agriculture Zoning Amendment); or set up urban beekeeping pilot projects (see Canada's "Bee City" designation or Toronto's "Pollinator Protection Strategy" adopted by the city council for relevant policy examples). The Baltimore example is especially noteworthy for its long-term planning approach to structuring urban agriculture into the landscape of the city, with considerations for equity in place.

However, legalizing the ability to grow food in cities (urban agriculture defined broadly) is not enough to promote equity and justice, nor resolve all the legal conundrums related to compliance with the terms of legislation (see Sustainable Economies Law Center website "Food Program" page for guidance materials provided to producers, as well as recommendations to improve legislative language going forward). Creating incentive zones for certain types of UA practices is not the same as creating supportive policies to allow and encourage the existence of the diverse array of practices and practitioners that constitute UA. Especially in cities with growing population and housing pressures (e.g., NYC, SF Bay Area), particular attention must be paid in policymaking to avoid advancing gentrification and displacement. This is less of a concern in cities without such housing pressures (e.g., Detroit, Milwaukee, Baltimore), but development is always a threat that must be considered when siting urban farms on private land. A promising policy direction pioneered by the City of Seattle is to dedicate public lands in low-income neighborhoods to UA, which Seattle does through its P-Patch program.

Other policy recommendations gleaned from the literature include: creation of a citywide UA task force with citizen representatives; efforts to tie in local "good food" ("not only healthy but also produced in a manner that respects animals and the environment and supports economic viability for all those along the way from farm to table"; Reynolds 2015) policies with city Climate Action Plans to promote UA and alternative food waste management alongside climate benefits[13]; devote public lands to urban farms and gardens in perpetuity; "retrofit" affordable housing developments with community gardens (following an affordable home solar installation model); provide public storage, transport, and aggregation options for urban farmers; and convert corner stores into neighborhood groceries offering fresh produce from local farms. Many of these efforts have potential to address many city priorities at once, for example: food access, nutrition and fitness, transportation, community development and crime reduction (Bolen and Hecht 2003). Providing land access for low-income and minority farmers is an important step towards ensuring a food supply that is culturally appropriate, desirable, and marketable to food insecure urban communities. By publicly confronting land insecurity and tenure arrangements, policymakers can directly respond to research on UA's uneven development (McClintock, Miewald and McCann 2017; McClintock 2014; Arnold and Roge 2018).

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[12] For an extensive review of city urban agriculture policies, see the American Planning Association magazine special issue on The Food Factor.

[13] Composting and anaerobic digestion were found in Mohareb, Heller and Guthrie (2018) to be the most effective component of reducing urban food systems' Greenhouse gas or GHG emissions

3.5.3. *Civic Engagement and Advocacy*

The most common form of civic participation in UA is through volunteer activities on urban farms. Smaller numbers of citizens are becoming involved in advocating for UA policies and improved zoning regulations that support food access goals, holding cities accountable to UA projects. Through direct participation, citizens are already voting with their feet in favor of UA initiatives (as summarized in Biewener 2016). Existing literature states, "'participants in a community garden continually express a heightened sense of self-esteem gained from sharing knowledge and skills with each other.' Such community connections can, in some cases, lead towards participation at the larger [policy] level" (Block et al. 2012). By expanding civic engagement into the local policy realm, it is more likely that sites designated, set aside, or incentivized for urban agriculture development will be strategically located, address food insecurity and food justice concerns, and provide long-term access for UA (Cohen 2016). Civic engagement can take many forms, including participating in neighborhood organizations, contacting elected officials and city councilmembers to communicate multiple values of UA, aligning UA with existing city plans/ordinances, or participating in food policy councils.

Citizen volunteers are participating in building community economies, often non-capitalist and non-exploitative in nature (depending on the form and structure of participation; see Biewener 2016 for a discussion of exploitative vs. non-exploitative unpaid work). Civic engagement advances the idea of creating "public commons" through urban agriculture, an idea related to ecological economics and explored in David Bollier's book *Think Like a Commoner: A Short Introduction to the Life of the Commons*. A commons "integrates economic production, social cooperation, personal participation, and ethical idealism into a single package;" it is a paradigm of "self-help and collective gain" and an "alternate self-governance structure for resource management and 'living well'" (Bollier 2014). The commons paradigm espouses a political philosophy grounded in grassroots civic activism and proposes different "foundational premises for a new political economy" based on social connections and rediscovering "people's knowledge" of natural systems in their local contexts (ibid.).

However, we must consider who is able to participate in creating such a space (who has time, energy, ability, agency, desire[14]). Who participates, in both policy and urban farming as an activity, is a crucial factor in determining whether outcomes will subvert or reinforce existing power, privilege and structural inequities. As Ramírez states, "While recreating neglected urban spaces into 'productive' spaces to grow food is inspiring and beneficial on one level, the prevalence of white bodies inhabiting garden spaces reifies uneven geographies and catalyzes gentrifying forces" (Ramirez 2014). It is the role of inclusive policy processes and watchdog citizen activists to counteract this retrogressive tendency of UA projects.

One example of grassroots political action, working around rather than through institutional channels of policymaking, is the Catatumbo Collective's people-to-people reparations project. Developed by three immigrant women spearheading an urban agriculture organization in Chicago, the people-to-people reparations map locates minority-run farming projects (both urban

[14] Desire is hindered in some cases by negative racial associations with farm labor held by African-American and Latino communities; as some authors state in summarizing work of black-led food justice organizations: "Clean Greens [urban farm in Seattle] also grapples with historical traumas of slavery that hinder the ability of even a black-led food justice organization to engage black residents in farming" (Ramirez 2014). By centering black food geographies, Ramírez argues such historical traumas can be overturned and re-envisioned, reclaiming urban farm spaces as centers of black liberation.

and rural) on a map of the United States, providing a brief description of the project and their specific needs, and then a link or contact info so that visitors can donate directly to the project. They are motivated to publicize agricultural history from a minority person's perspective and provide a means of public accountability through their mapping project, supporting "those who have borne the brunt of labor exploitation, land theft, and discriminatory agricultural policy" (Posner 2018). This project has already led to funding for several farmers' projects, as well as land gifts to create several minority-owned farms. While the founders recognize the need to continue litigation and action through formal policy channels, they honor the urgency of needing to "start right away" by facilitating "transfers of wealth." They are also contributing to a more updated database of farmers of color, often underrepresented in USDA farm censuses.

There is room for more participatory action research linking researchers to citizens and civic engagement projects (e.g., Haletky and Taylor 2006). This will allow for data to be shared and transferred more easily, and for the network of UA and food justice participants to strengthen through ties to research institutions and each other. Researchers have an important role to play in addressing data gaps and strengthening the network of urban farmers who have clearly identified needs and are ready to work towards appropriate, measurable solutions.

3.6 Reframing UA as a Public Good: Using an Equity and Systems Lens to Integrate UA Into Municipal Policy and Planning Efforts

According to the literature, access to urban-produced foods is directly tied to the economic realities of urban farming operations. Daftary-Steel, Herrera, and Porter (2015) make a compelling case for building coalitions to provide the necessary political and financial support to fund UA, as well as tackling the "root causes" of food insecurity through social services. From what limited studies exist, it seems clear that economic viability of urban farms is dependent on income far beyond sales capacity of the urban farm.

Moving the conversation into the policy realm is vital. It is important to communicate to policy makers that urban farms are producing a lot more than pounds of food; they are also "distributing" social goods, creating a "commons", and providing a connection to nature, community, and education (culinary, nutrition and food literacy), and these in turn are part of improving community food security. The primary benefits of UA organizations are often education (around nutrition and food literacy), social integration, economic opportunity, and local environmental quality improvements. Producing enough food to transition a community from "food insecure" to "food secure" is not necessarily going to happen through urban farming alone; however, supplementing food intake with locally produced, healthy fruits and vegetables is an important step in building food security and community health. As such, researchers and UA practitioners may consider generating more robust data on the health, environmental and social benefits of UA to promote among policy makers the idea of UA as a public good, worthy of public investment in the same vein as schools, transportation and education. This is especially true in U.S. cities without strong policies supporting the existence of UA, and with high land values and development pressures.

It is important to acknowledge that urban agriculture is not the only solution to food insecurity and food access and should not be the only forum of support/intervention from policymakers. In fact, in some cases "the emphasis on 'grow your own' reinforces self-help and government austerity arguments, absolving government of the responsibility to address the structural and institutional causes of food insecurity" (Horst et al. 2017). UA is part of the solutions portfolio to improve food justice and food access, but must be complemented and reinforced by other governance efforts to provide affordable, healthy food through neighborhood groceries, food hubs, cooperative markets, culinary and nutrition education programs, farm to school programs or other means of addressing structural causes of food insecurity (e.g., poverty and job access). Civic engagement, critical scholarship from multidisciplinary perspectives, and alliances between housing, transportation, and food policy are all necessary components of a UA landscape that improves access and meets the needs of both producers and consumers.

In conducting this literature review, using a combination of academic and gray literature, we recognize a significant gap between scholarship and practice. Urban agriculture is not a panacea that will automatically produce all the social, environmental, and economic "goods" attributed in the literature at large without proper structuring or policy frameworks in place. A more realistic, and holistic picture of urban agriculture can be advanced by further rigorous evaluation of what particular organizations are choosing to focus on, how much food they are producing currently (vs. potential), how they are distributing their food, and where they need support. It is not just about whether urban farms have the *potential* to feed food insecure people, but whether they actually do, depending on locally specific modes of distribution, channels of access, and policy climates. Key ideas from the literature about how to enable socially just, economically viable urban agriculture include a focus on food sovereignty, public investment and/or land rights, "agrihood" developments, and attention to disparate neighborhood race and class dynamics when siting UA operations.

Researchers can address key data gaps including the actual tracking and consumption of urban-produced food. We can answer lingering questions including: where does the food go, how much is accessed vs. wasted, what are consumer preferences around accessing urban-produced foods, and where do institutions need to fill in gaps in access and/or distribution channels? Results of this literature investigation are next applied to our ongoing study of urban agriculture in the East Bay region of the San Francisco Bay Area, characterized by a high amount of urban agriculture activities (and deep history in the origins of the alternative food movement), yet undergoing rapid gentrification with persistent high levels of food insecurity and income inequality.

3.7 From Urban Agriculture to Urban Agroecology

Despite growing evidence of the diverse health, education, and environmental benefits of urban agriculture, these vibrant spaces of civic engagement remain undervalued by city policy makers and planners in the United States. Because urban farming takes on many different forms and functions, with intended outcomes that may or may not include yield and profits (Poulsen, Neff, & Winch 2017), thriving urban farms and gardens are under constant threat of conversion to housing or other competing, higher-value land uses due to rising land values, and other city priorities. This land use challenge and threat to urban farm land tenure is especially characteristic of U.S. cities like San Francisco, one of the most expensive land and housing markets in the country.

Under the current urban agriculture paradigm in the U.S., food justice scholars and advocates either try to quantify and highlight the multiple benefits of UA (including but not limited to an ongoing focus on the productive potential of urban farming) (see reviews by Golden 2013 and Santo et al. 2016) or pursue a critical theoretical approach, arguing that urban agriculture can yield unfavorable results if pursued without an equity lens, especially in cities with intense development pressures and gentrification concerns (Horst et al. 2017; McClintock, Miewald & McCann 2018; Sbicca 2012). A productivist focus is problematic, because, while urban agriculture can be an important component of community food security, its other social and ecological benefits are just as, and sometimes more, significant (Siegner, Acey and Sowerwine 2018). In this article, we suggest that the current debates around "urban agriculture" in the U.S. often lead to an unhelpful comparison with rural farms regarding yield, productivity, economic viability, and ability to feed urban populations, most notably in the policy arena. Defined in these ways, the radical, transformative potential of urban food production spaces and their preservation often gets lost or pushed to the side in city planning decisions in metropolitan regions such as the San Francisco Bay Area, where the threat of displacement is ubiquitous given high levels of economic inequality and extreme lack of affordable land.

In order to facilitate what scholars such as Anderson et al. 2018a refers to as the "agroecological transition," already underway in many urban food ecosystems around the globe (see Renting 2017), we argue that applying an agroecological approach to inquiry and research into the diversity of sites, goals, and ways in which food is produced in cities can help enumerate the synergistic effects of urban food producers. This in turn encourages the realization of the transformative potential of urban farming, and an articulation of its value meriting protected (or planned) space in urban regions. Urban agroecology (UAE) is an evolving concept that includes the social-ecological and political dimensions as well as the science of ecologically sustainable food production (Altieri & Nichols 2019; Tornaghi 2016; Dehaene et al. 2016). UAE provides a more holistic framework than urban agriculture to assess how well urban food initiatives produce food and promote environmental literacy, community engagement, and ecosystem services.

This paper presents a case study of 35 urban farms in San Francisco's East Bay in which we investigated key questions related to mission, production (including inputs and outputs), labor, financing, land tenure, and educational programming. Our results reveal a rich and diverse East Bay agroecosystem (i.e. the network of urban farmers and their connection to and interaction with food justice organizations, NGOs, food policy councils, school gardens, and other food system actors) engaged in varying capacities to fundamentally transform the use of urban space and the regional food system by engaging the public in efforts to stabilize, improve, and sustainably scale urban food production and distribution. Yet, as in other cities across the country, they face numerous threats to their existence, including land tenure, labor costs, development pressure, and other factors that threaten wider adoption of agroecological principles.

We begin by comparing the concepts of UA and UAE in scholarship and practice, bringing in relevant literature and intellectual histories of each term and clarifying how we apply the term "agroecology" to our analysis. We pay particular attention to the important non-ecological factors that the literature has identified as vital to agroecology, but seldomly documents (Palomo-Campesino et al. 2018). We then present findings from a survey of 35 diverse urban farm operations in the East Bay. We discuss the results, showing how an agroecological method of inquiry amplifies important aspects of urban food production spaces and identifies gaps in national urban agriculture policy circles. We conclude by positing unique characteristics of *urban* agroecology in need of further studies and action to create equitable, resilient and protected urban food systems.

3.7.1 Definitions of Urban Agriculture

Agricultural policy in the United States is primarily concerned with yield, markets, monetary exchange, and rural development. The United States Department of Agriculture (USDA) defines agricultural activities as those taking place on farms. Farms are defined as "any place from which $1,000 or more of agricultural products were produced and sold, or normally would have been sold, during the year" (USDA ERS). Urban agriculture has been proliferating across the country in the last decade on both public and private lands, as both for-profit and non-profit entities, with diverse goals, missions and practices largely centered on food justice priorities and re-localizing the food system. Yet U.S. agriculture policy has been struggling to keep up. In 2016, the USDA published an Urban Agriculture Toolkit, which aims to provide aspiring farmers with the resources to start an urban farm including an overview of the startup costs, strategies for accessing land and capital, assessing soil quality and water availability, production and marketing, and safety and security (USDA 2016). The 2018 U.S. Farm Bill provides a definition of urban agriculture to include the practices of aquaponics, hydroponics, vertical farming, and other indoor or controlled environment agriculture (CEA) systems primarily geared towards commercial sales. In both the Toolkit and Farm Bill, non-profit, subsistence, and educational urban farming enterprises are not well integrated or included in the conceptualization of (and therefore, available funding for) UA.

While there are many definitions of urban agriculture in the literature from the simplest definition of "producing food in cities" (McClintock, Miewald & McCann 2018) to longer descriptions of UA such as that of the American Planning Association that incorporate school, rooftop and community gardens "with a purpose extending beyond home consumption and education," the focus of many UA definitions used in policy arenas continues to center around the production and sale of urban produced foods. Accordingly, food systems scholars have recognized that "Urban agriculture, [as defined], is like agriculture in general", devoid of the many political, educational, and food justice dimensions that are prioritized by many U.S. urban farming efforts. Thus the social-political nature of farming, food production, and food sovereignty are not invoked by formal UA policy in the U.S.

Many goals and activities common in urban food production, including education, non-monetary forms of exchange, and gardening for subsistence are obscured by the productivist definitions and can be thus neglected in policy discussions. Furthermore, UA policy in the U.S. remains largely agnostic about the sustainability of production practices (other than assessing soil contamination risk) and their impact on the environment. While U.S. agriculture policy narrowly focuses on the production, distribution and marketing potential of UA, broader discussion of its activities and goals proliferate among food systems scholars from a range of fields including geography, urban planning, sociology, nutrition, and environmental studies. These scholars are quick to point out that UA is much more than production and marketing of food in the city and includes important justice elements (Agyeman & McEntee 2014; Alkon & Norgaard 2009; Alkon & Agyeman 2011).

In the Bay Area context, we continue to see the result of this dichotomy: thriving urban farms lose their leases (Arnold & Roge 2018), struggle to maintain profitability or even viability (Daftary-Steel et al. 2015) and encounter difficulties creating monetary value out of their social enterprises. In light of the ongoing challenge to secure longevity of UA in the United States, there is a need for an alternative framework through which food and farming justice advocates can better understand and articulate what UA is, and why it matters in cities.

3.7.2 Urban Agroecology in the United States

Agroecology is defined as "the application of ecological principles to the study, design and management of agroecosystems that are both productive and natural resource conserving, culturally sensitive, socially just and economically viable" (Altieri and Toledo 2011; Gliessman 2012; quoted in Tornaghi 2016), and presents itself as a viable alternative to productivist forms of agriculture. Agroecology in its most expansive form coalesces the social, ecological, and political elements of growing food in a manner that directly confronts the dominant industrial food system paradigm, and explicitly seeks to "transform food and agriculture systems, addressing the root causes of problems in an integrated way and providing holistic and long-term solutions" (FAO 2018). It is simultaneously a set of ecological farming practices and a method of inquiry, and, recently, a framework for urban policymaking ("agroecological urbanism"); "a practice, a science and a social movement" (Wezel et al. 2009).

Agroecology has strong historical ties to the international peasant rights movement La Via Campesina's food sovereignty concept, and a rural livelihoods approach to agriculture where knowledge is created through non-hegemonic forms of information exchange, i.e. farmer-to-farmer networks (Holt-Gimenez 2005, Gliessman 2015). Mendez et al. (2013) describe the vast diversity of agroecological perspectives in the literature as "agroecologies" and encourage future work that is characterized by a transdisciplinary, participatory and action-oriented approach. In 2015, a global gathering of social movements convened at the International Forum of Agroecology in Selengue, Mali to define a common, grassroots vision for the concept, building on earlier gatherings in 2006 and 2007 to define food sovereignty and agrarian reform. The declaration represents the views of small scale food producers, landless rural workers, indigenous peoples and urban communities alike, affirming that "Agroecology is not a mere set of technologies or production practices" and that "Agroecology is political; it requires us to challenge and transform structures of power in society" (Nyéléni 2015). The declaration goes on to outline the bottom-up strategies being employed to build, defend and strengthen agroecology, including policies such as democratized planning processes, knowledge sharing, recognizing the central role of women, building local economies and alliances, protecting biodiversity and genetic resources, tackling and adapting to climate change, and fighting corporate cooptation of agroecology.

Recently, scholars have begun exploring agroecology in the urban context. In 2017, scholars from around the world collaborated on an issue of the *Urban Agricultur*e magazine titled "Urban Agroecology," conceptualizing the field both in theory and through practical examples of city initiatives, urban policies, citizen activism, and social movements. In this compendium, Van Dyck et al. (2017) describe urban agroecology as "a stepping stone to collectively think and act upon food system knowledge production, access to healthy and culturally appropriate food, decent living conditions for food producers and the cultivation of living soils and biodiversity, all at once." Drawing from examples across Europe, Africa, Latin America and Asia and the United States, the editors observe that urban agroecology "is a practice which - while it could be similar to many 'urban agricultural' initiatives born out of the desire to re-build community ties and sustainable food systems, has gone a step further: it has clearly positioned itself in ecological, social and political terms" (Tornaghi and Hoekstra 2017).

Urban agroecology takes into account urban governance as a transformative process and follows from the re-emergence of food on the urban policy agenda in the past 5-10 years. However, it requires further conceptual development. Some common approaches in rural agroecology do not necessarily align with urban settings, where regenerative soil processes may require attention to industrial contamination. In other cases, the urban context provides "specific knowledge, resources and capacities which may be lacking in rural settings such as shorter direct marketing channels, greater possibility for producer-consumer relations, participatory approaches in labour mobilisation and certification, and initiatives in the area of solidarity economy" (Renting 2017).

Focusing on the social and political dimensions of agroecology, Altieri and others have explicitly applied the term "agroecology" to the urban context, calling for the union of urban and rural agrarian food justice and sovereignty struggles (Altieri & Nichols 2019; Tornaghi 2016; Dehaene et al. 2016; Montenegro de Wit 2014). Dehaene et al. (2016) speak directly to the revolutionary potential of an agroecological urban food system, building towards an "emancipatory society" with strong community health and justice outcomes. They go on to argue that UAE is a new model for sustainable urbanization:

> "It is a way of conceiving of a city, its functions, zoning, green infrastructure, and governance, within an agroecological perspective where human wellbeing is fundamentally connected to food production and where this cannot be left to uneven forms of market allocation, dictated by wealth, opportunism, or profitability, but rather by a coherent agenda for social emancipation that recognises its constitution within ecological relations."

Our research builds upon this emergent body of work that employs urban agroecology as an entry point into broader policy discussions that can enable transitions to more sustainable and equitable city and regional food systems in the U.S. (Anderson et al. 2018a). This transition in UAE policymaking is already well underway in many European cities (see Anderson et al. 2018b).

As noted, there are many dimensions of agroecology and ways in which it is conceptualized and applied. We employ the 10 elements of agroecology recently developed by the UN FAO (FAO 2018) in our discussion of urban agroecology[15]. These 10 elements characterize the key constituents of agroecology including the social, ecological, cultural, and political elements. Despite the emancipatory goals of agroecology, a recent review of the literature by Palomo-Campesino et al. (2018) found that few papers mention the *non-ecological* elements of agroecology and fewer than 1/3 of the papers directly considered more than 3 of the 10 FAO-defined elements. In an effort to help guide the transition to more just and sustainable food and agricultural systems in cities across the U.S., we propose that food system scholars and activists consider using the 10 elements as an analytical tool to both operationalize agroecology, and to systematically assess and communicate not only the ecological, but also the social, cultural and political values of urban agroecology. "By identifying important properties of agroecological systems and approaches, as well as key considerations in developing an enabling environment for agroecology, the 10 Elements [can be] a guide for policymakers, practitioners and stakeholders in planning, managing and evaluating agroecological transitions (FAO 2018)[16].

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[15] The 10 Elements of Agroecology are based primarily on the seminal scientific literature on agroecology – in particular, Altieri's (1995) five principles of agroecology and Gliessman's (2015) five levels of agroecological transitions. This scientific foundation was complemented by participatory discussions held in workshop settings during FAO's multi-actor regional meetings on agroecology from 2015 to 2017, which incorporated civil society values on agroecology, and subsequently, several rounds of revision by international and FAO experts (FAO 2018).

[16] The ten elements are: 1) diversity 2) co-creation and sharing of knowledge 3) synergies 4) efficiency 5) recycling 6) resilience 7) human and social values 8) culture and food traditions 9) responsible governance and 10) circular and solidarity economy (See Appendix A for descriptions of each element).

Our study builds on foundational work promulgating the concept of UAE by providing important grounding of the theoretical elements of agroecology tied to what we see in practice on East Bay urban farms.

3.8 Applying and Urban Agroecological Conceptual Framework to the East Bay Region of San Francisco

3.8.1 Case Study Context

In San Francisco's East Bay region, urban food production proliferates in schoolyards, in half-acre lots converted to urban farms, on rooftops, and in backyards reflecting a diversity of participants, goals, impacts and challenges (McClintock 2011; McClintock, Cooper & Khandeshi 2013; Bradley & Galt 2014; Haletky & Taylor 2006). The San Francisco East Bay region is also experiencing rapid gentrification and a worsening affordable housing crisis coupled with high rates of income inequality and food insecurity[17]. The challenge of urban soil contamination creates tradeoffs for aspiring growers between vacant lot availability and siting on the most heavily polluted plots (see McClintock 2012 for an analysis of East Bay soil contamination). Specific city policies vary in the degree to which they support or discourage urban agricultural activities, and availability of arable land across the East Bay is uneven.

Our case study focuses on urban farmers in the East Bay spanning over 28 miles (45 kilometers) from El Sobrante in the northeastern edge of the bay, to Hayward in the southern

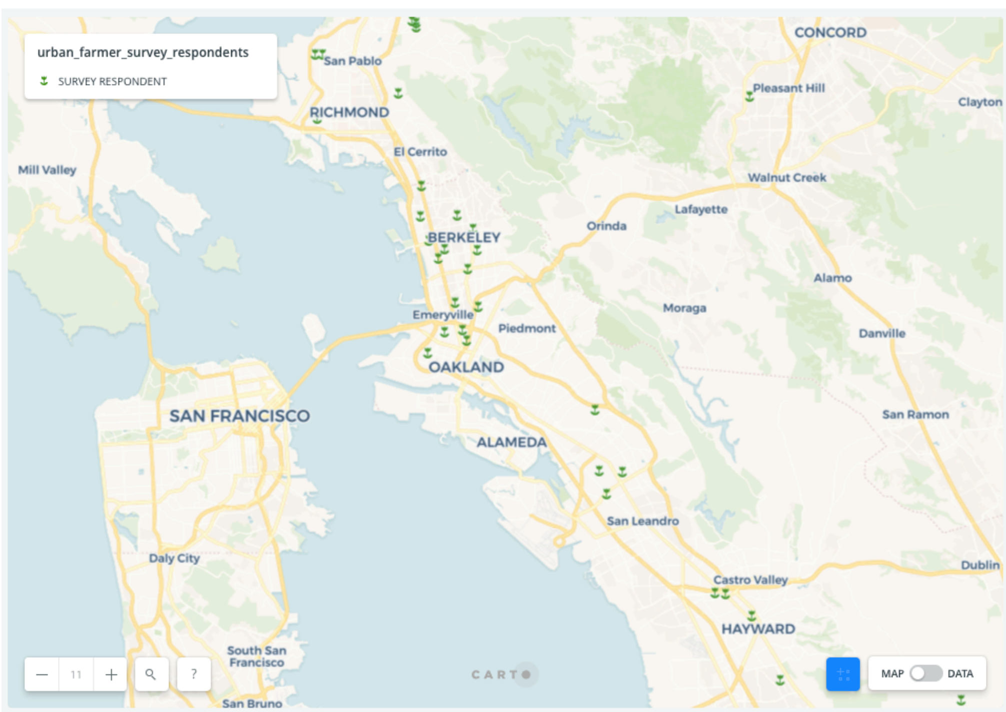


Figure 13- Location of Survey Respondents

[17] One in five residents of Alameda County rely on food bank assistance to feed themselves and their families, and over half of food bank patrons have worked for pay in the past year, reflecting the increasingly unaffordable costs of living in the region (Alameda County Community Food Bank 2014).

East Bay as shown in Figure 13. We include both for-profit and non-profit farms ranging from educational school gardens to roof-top farms marketing microgreens.

3.8.2 Methodology

We employed a participatory and collaborative mixed methods approach, involving diverse stakeholders from the East Bay Agroecosystem. We held two stakeholder input sessions involving over 40 urban farmers and food advocates to co-create the research questions, advise on the data collection process, interpret the results, and prioritize workshop topics for the community.

We administered an online Qualtrics survey to 120 urban farms in the East Bay that had been previously identified by the University of California Cooperative Extension (UCCE) Urban Agriculture working group and additional outreach. The survey launched in Summer 2018, which is a particularly busy time for farmers, and in response to farmer feedback was kept open until November 2018. 35 farmers responded in total, representing a 30% response rate. While there are limitations in our ability to generalize findings to the East Bay urban farming landscape as a whole due to the relatively small sample size, we obtained a fairly representative sample of the diversity of farm types in the East Bay based on our typology of the original 120 farm types (10% for profit, 90% non-profit). Survey questions fell into nine categories: 1) Background Info, 2) Farm Description, 3) Operating Expenses and Revenues, 4) Land Access and Tenure, 5) Production and Soil Health, 6) Distribution, 7) "Waste" and Compost, 8) Food Access, and 9) Training, Communications, and Follow Up. There were a few open-ended questions allowing farmers to express what they saw as the three largest challenges facing urban agriculture operations in the area, and policy-relevant suggestions for securing spaces for urban farms and increasing community food security.

In addition, we interviewed five urban farmers to deepen our understanding of the social, political, economic, and ecological constraints under which their farms operate. These farmers are particularly involved in networking efforts to strengthen urban farm viability in the East Bay. Four out of five represent locally prominent non-profit farms and one subject represents an alternative cooperatively-run urban farm; three interview subjects are women and two are men. Our study complied with UC Berkeley's Institutional Review Board (IRB) protocol (CPHS Protocol 2018-02-10698) for the protection of human subjects and all participants gave consent for participation.

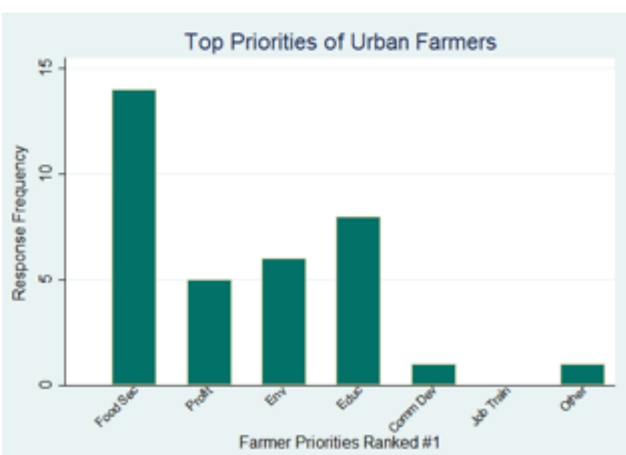


Figure 14- Mission of Urban Farmers

3.8.3 Data analysis

We analyzed our survey data using STATA (14.1) to generate descriptive statistics as well as to explore relationships among variables. Interviews and long response data from the survey were coded and analyzed using Atlas TI (8.3.1). The authors jointly identified 57 codes using both deductive and inductive methods, and the lead author coded the data.

Spatial analysis of food distribution networks in ArcGIS and Carto provides insight into the diversity of organizations receiving urban produce, the value of informal food distribution networks, and the volumes of food that are distributed through donations and for volunteer consumption.

3.9 Results from the East Bay Agroecosystem

Respondent characteristics: The majority of our survey respondents were non-profit operations (77%) headed by women (62%). The nonprofits represent a diversity of farm types including educational, school or church-based, university, and community gardens; many are affiliated with or co-located at public institutions such as the Oakland Parks and Recreation Department. Urban farms ranged in size from 0.1 to 4.5 acres with an average size of 1.8 acres and have been in operation from 1 to over 10 years. The top three highest ranked farm missions were community food security (CFS), food sovereignty, and food justice (#1), education (#2) and environmental sustainability (#3), whereas the lowest ranked missions were job creation (#6) and profit (#5) (See Figure 14).

3.9.1 Agroecological Practices

Crops Diversity and Regenerative Farm Practices: Urban farms in our study are highly diversified, producing on average 4.5 different categories of food products including vegetables, fruits/nuts, flowers, poultry and small ruminants, bees, culturally relevant crops, and grains. The crops most frequently grown on East Bay urban farms are vegetables and fruits, followed by flowers to attract beneficial insects. Respondents who own the land that they farm were slightly more likely to grow fruit/nut trees, but not significantly (chi-squared $p = 0.091$). Over half of the farms ($n = 18$) reported cultivating bees for honey and pollination services, speaking to a broader dialogue around ecosystem services provided by urban farms. Smaller numbers of farms reported raising chickens (for both meat and eggs; $n = 14$), small mammals ($n = 3$), and grains ($n = 3$). There is a positive but not significant correlation between farm size and crop diversity ($r = 0.4666$, $p = 0.2438$), and a positive, significant association between crop diversity and number of soil health practices used ($r = 0.3608$, $p = 0.0361$). Production practices are intentionally regenerative, with 83% of farmers reporting use of at least 3 soil building practices including cover cropping, no-till, compost and manure amendments, and crop rotation. The motivation for these practices comes from both desire to adopt climate friendly practices, and a pragmatic need to amend and build poor urban soils allowing for crop productivity.

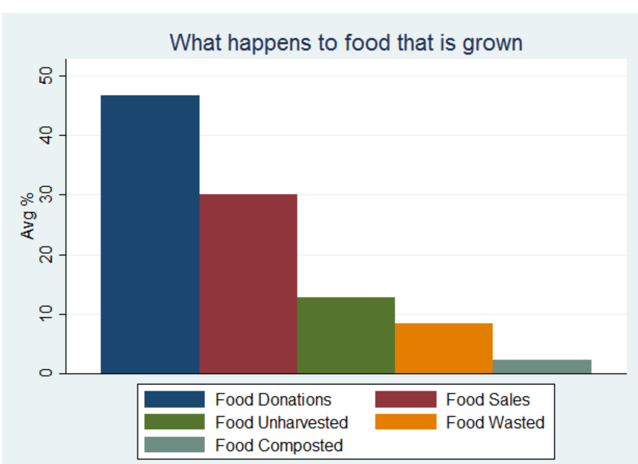
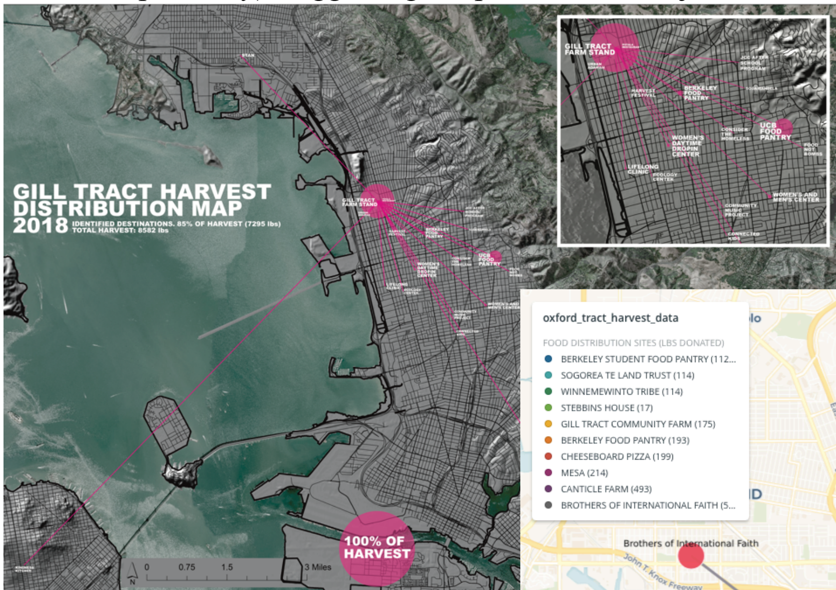


Figure 15- What happens to urban produce

Circular and Solidarity Economy: A significant percentage of the food (45%) produced on urban farms in the East Bay is donated rather than sold to consumers (See Figure 15). The percentage of donated food positively correlates with nonprofit status ($r = 0.5182$, $p = 0.0017$) and those farms that ranked food security as a top priority ($r = 0.4238$, $p = 0.0125$), while for profit operations positively correlate with higher percentages of food sales ($r = 0.6531$, $p = 0.0000$). From some nonprofit respondents, up to 97% of the food was donated, while from two for-profit operations, up to 90% of the food was sold. Food donations surprisingly are negatively correlated with total revenue from grants, (r= -0.2482, -0.3665, and p = 0.1636, 0.0854 respectively), suggesting the powerful social justice mission of even farms with the lowest revenues.



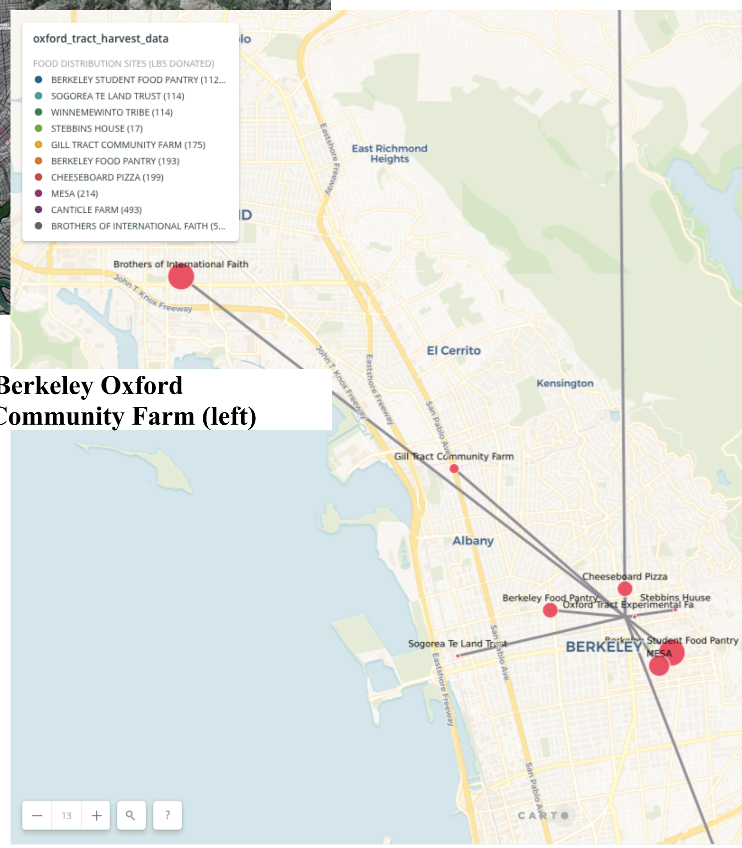


Figure 16- Distribution Network from U.C. Berkeley Oxford Experimental Tract (below) and Gill Tract Community Farm (left)

Most farms including the UC Oxford Tract and Gill Tract Farms, distribute food to a diverse array of community organizations, (see Figure 16). The two aforementioned farms together distribute food to over 50 community organizations, ranging from food pantries to community health groups to native land trusts seeking to feed and reclaim land for those of indigenous heritage. 52% of respondents distribute all food within 5 miles of their farm, while 70% distribute within 10 miles. Produce from each farm site reaches approximately 250 people per week on average during the peak growing season, or approximately 7,000 people from all surveyed farms. Customers reached is moderately correlated with total revenue (r = 0.3794, p = 0.0510) suggesting a growing impact on CFS as farms access additional income.

Farmers reported diversified distribution methods including volunteers harvesting and taking food home (63%), on-site consumption (particularly at schools are where basic kitchen equipment is available), on-site farm stand distribution, CSA boxes at pick up sites, and volunteers delivering produce directly to distribution sites (food pantries, etc.). Some gleaning and second harvesting occur at urban farms and gardens (20%) with potential for growth given reported "unharvested" and "wasted" food percentages. Backyard produce is also exchanged through crop swaps and neighborhood food boxes (20%). Eight operations reported having access to a refrigerated truck for food deliveries, and two are willing to share their truck with other farmers. There is no universally used or city-organized process for distributing produce off of urban farms and into the community, yet there exists great interest in aggregating produce or distribution channels (of interest to over 90% of respondents, primarily in order to reach more food insecure people), an unrealized goal of urban farmers in the East Bay.

All of the food system stakeholders involved in our study are working towards transformative food system change, focused on increasing equity, food security, and access to healthy, locally sourced food. See Box 1 for a description of one of the non-farmer stakeholders engaged in the food recovery and distribution system, who has recently established an aggregation hub to serve as a network for reducing food waste and channeling excess food in the urban community to those who are food insecure.

Box 1. Sara Webber and the Berkeley Food Network

Sara Webber is the founder of the Berkeley Food Network (BFN), an initiative that provides bags of food and prepared meals to those experiencing food insecurity who are not currently served by the emergency food distribution (food bank/food pantry) network. BFN delivers food to over 800 individuals each month through senior centers, schools, and other community centers, partnering with commercial kitchen spaces in order to provide warm meals in addition to raw food bags. BFN just recently established its own storage space after receiving city approvals and permits, which allows recovery and storage of additional amounts of perishable food to better serve the existing need. BFN plans to partner with local urban farmers to recover food donations and currently un-harvested food "waste" from these farms to use for raw food bags and value-added processing. They are working to acquire additional refrigerated storage space as well as access to a truck and paid delivery staff to fully achieve its vision. BFN is poised to provide valuable assistance to urban farms who struggle to distribute all produce, lacking time and infrastructure to harvest and deliver at full potential.

Human and Social Values: Farmers in our study stressed the importance of producing *non-food* related values on their farms, including education and community building. One farmer in particular emphasized their organization's mission of "growing urban farmers growing food," or teaching other people how to grow a portion of their food basket, thus unlocking food sovereignty and food literacy while increasing healthy food access. Another respondent reported that their farm is "highly desirable for adults with special needs that need a safe place to be outside," echoing respondents who point out the intimate connection between food and health (mental, physical, emotional, and spiritual). Farms frequently reported hosting educational and community-building workshops, cooking and food processing demonstrations, harvest festivals, and other open-to-the-public community events enhancing the resilience and connectivity of people, communities and ecosystems. Social networks emerged as an important theme for enabling the establishment of urban farms (e.g. due to a church contact allowing a member to start a church-supported garden) and sustaining operations through social connections between urban farmers and other food justice and health advocates. One farmer described food production and access from a human rights perspective, stating: "We live in a society that is based on profit not human needs. We believe access to healthy organic local food should be a *basic right* for all of the people."

3.9.2 Threats to the Agroecosystem and Farmer Perspectives on Urban Policies

"The high price of operating a farm makes it difficult to sustain unless there is general support from the national, state or local level. This is something we need to repeat again and again until there is the political will to see that growing food locally is something worth supporting financially- and seeing it as a public health, as well as an environmental issue. Farming is so misunderstood in our society. Many consumers of food don't know the challenges involved in the growing food, and so don't see it as an important 'service' to support" (Survey Respondent, Fall 2018).

Farmers identified three primary challenges: revenue, land, and labor inputs. Half of all respondents reported farm earnings of $1,500 annually or less (see Figure 17), and all four operations receiving over $250,000 in annual revenue are well-funded non-profit operations. Regardless of for-profit or non-profit status, most farms reported multiple sources of revenue as important to their continued operation (e.g. grants, fundraisers, educational events, space rentals for community workshops, and donations in addition to produce sales), with an average of 3 revenue streams per farm. All non-profit farms reported multiple revenue streams except for three, who were sustained entirely by either board donations, membership fees (in the case of a community garden), and grants. The most important revenue sources for non-profits include grants, grassroots fundraising, and unsolicited donations rather than sales. In addition to these monetary sources, all farms reported receiving substantial non-monetary support (e.g. in-kind donations, exchanges, low-cost lease agreements with the city or landowner, and resource sharing built around personal relationships), which adds to the precarity of operations when these informal support channels disappear.

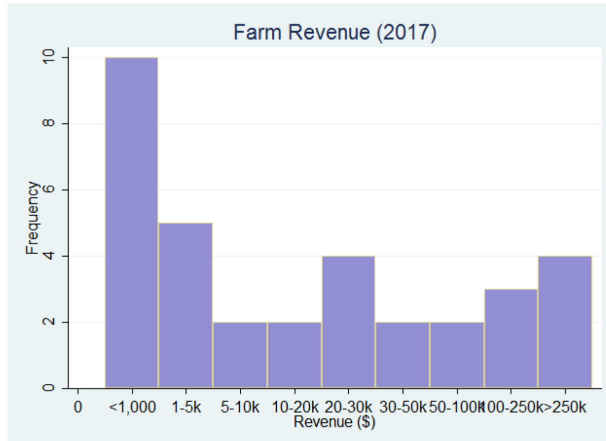


Figure 17- Urban Farm Annual Revenue

Land and Labor Inputs: Land tenure arrangements range from land accessed without payment through contracts with City or School District officials, to arrangements where a token fee is paid (i.e. $12/year or $1 for 40 years), to more formal leasing arrangements at the utility-owned Sunol Ag Park, where (mostly for-profit) land tenants pay $1000/acre/year for their plots, ranging from 1-3 acres. Only five of the respondents owned their land (14%), representing a mix of for-profit (2) and nonprofit operations (3). Challenges around land access, security, and tenure were the most frequently occurring theme in the survey long response and interview analysis process, including consensus that land access is the largest barrier to scaling UA in the East Bay.

The cost of labor, and relatedly, access to capital and grant funding to pay living wage salaries, were also extremely significant challenges identified by survey respondents. The majority of respondents stated that most of their labor is volunteer rather than paid, with non-profit respondents reporting this more frequently (71% volunteer driven operations) than for profit enterprises (50% volunteer/unpaid intern driven). The maximum number of paid staff (part time, full time or internships) at any operation is 20 (in the case of a college farm with paid summer student interns), while the average is 4. Many farms reported the desire to be able to hire and pay workers more, but not having sufficient revenue to accomplish that goal. Annual volunteer labor participants on farms ranged from 0 to 1542 with an average of 97 volunteers, representing a significant public interest in participating in local food production. Not surprisingly, amount of paid labor and total farm income are positively correlated (r = 0.6498, p= 0.0000). However, volunteer labor is also positively but more moderately correlated with total farm income (r = 0.3588, p = 0.0372).

Farmers also expressed a desire to enhance race and ethnic diversity in terms of labor participation, with 16 farms indicating interest in learning how their farm can better address racial justice and equity through operations and participation.

Policy (and non-policy) Recommendations from Growers- The farmers in our study acknowledged many challenges facing urban agriculture, stemming both from the high economic costs of production and land rents, and insufficient monetary returns from produce sales. They also framed these challenges through a food justice lens, arguing that the current political economy does not fully compensate farmers for the social-ecological services provided from their farms.

Farmers articulated many solutions that could improve the viability of their farm operations including: conversion of city parks into food producing gardens with paid staff, government and institutional procurement goals for urban produced foods, municipal investment in cooperatives or other community based food production (aquaponics), and establishment of aggregation hubs and distribution infrastructure.

Box 2. Vision for Cooperative Aquaponics

"To create the kind of systemic change we need to see… we need [solutions like cooperative aquaponics systems]... If we were growing half a million pounds or so of produce in the aquaponics farm, and open sourcing the technology, training people how to do it, and then ***starting a producers cooperative*** *that would help people get access to much smaller lots… and you could replicate the technology on a smaller scale, and buyers would be set up through Planting Justice's existing connections with Kaiser, OUSD, and other* ***anchor institutions****… we'd be* ***lowering the barrier to entry*** *so people could just learn how to grow the food and not have to worry about the business planning and all of these bureaucratic hurdles"*

3.10 Discussion and Conclusion

Our survey results describe a highly diversified East Bay Agroecosystem comprising urban farmers and other food system stakeholders that are growing food as well as food literacy, civic engagement, connectivity, and community. Applying an agroecological lens to interpret our findings of East Bay urban agriculture operations reveals the many agoecological practices farms have long been engaged in, as well as the important distinctions of UAE that still need to be explored, and specific threats to agroecology in urban areas. Pimbert (2017) suggests that "agroecology's focus on whole food systems invites urban producers to think beyond their garden plots and consider broader issues such as citizens' access to food within urban municipalities and the governance of food systems." We argue that applying an agroecological lens to the urban context *also* invites researchers and urban planners and policymakers to think beyond garden plots and singular benefits of food production, to consider these sites as part of a larger agro-ecosystem with synergistic social, cultural and ecological dimensions. We reference the 10 elements of agroecology to illustrate the dynamics of how these elements manifest in practice in this urban context.

Agroecological Practices. All of the farms in our survey follow agroecological production practices which include a focus on building soil health through, most commonly, cover cropping, compost application, and no-till practices. These practices produce synergistic effects of adding fertility to the soil through organic matter amendments and boosting water holding capacity. Soil building practices are a response to the impetus to remediate toxins present in urban soils (which may be contaminated with lead and other heavy metals as well as ambient air and industrial pollutants), a prerequisite to intensive cultivation and unique consideration of the urban farm environment. Overall, production practices on our urban farms seek to conserve, protect and enhance natural resources.

Our survey respondents described numerous strategies for enabling diversified, intensive production of fruits, vegetables, and other agricultural products. These strategies span both short and long-term, from planting in raised beds with imported soil, to building soil health in situ via heavy applications of compost, manure, and cover crops for several years leading up to vegetable crop production. There is a growing interest in using no-till practices, which are among the suite of practices associated with "carbon farming" for enhancing soil carbon sequestration (Paustian et al. 2016). This illustrates a synergistic opportunity for urban food policy and urban climate policy, showing where urban food production and city Climate Action Plans (CAPs)[18] can converge and generate mutual support (see Mohareb et al. 2017 & 2018 for specific examples of urban food systems participation in GHG reduction policies; also Shattuck et al. 2016). Farmers are also engaged in innovative resource recycling and resource use efficiency and other strategies to enhance resilience such as installing rainwater catchment systems in concert with swales and soil health practices to optimize use of this scarce resource. Farms are planting native flowers and shrubs to attract beneficial insects, rather than purchasing chemical inputs for pest management. From a city planning perspective, the impetus to remediate stormwater overflows and maintain corridors for essential pollinators are two priorities that can be met through incentivizing and planning spaces for UAE.

Overcoming Threats to Urban Agroecological Operations. Diversification is key to agroecological transitions.

East Bay urban farms reflect multiple scales and forms of diversity including agrobiodiversity, organizational and participant diversity, diversified sources of capital, labor and land arrangements, as well as diversified modes of exchange. Diversity among operations technically doing the same thing- growing food in cities- signals the fluid, flexible, peripheral, and at times revolutionary nature of urban food production spaces, which may conflict with or resist the institutional, political-economic status quo (e.g. Van Dyck et al. 2018; Tornaghi 2016; Alkon and Norgaard 2009).

Urban farms rely on diverse revenue streams from their diversity of activities beyond sale of produce. These activities, including educational services and community events, are important to elevate in policy conversations. Valuing and therefore protecting urban food production spaces requires thinking differently about them in a context like the San Francisco Bay Area.

[18] The City of Berkeley's recent Urban Agriculture Ordinance creates an explicit link between supporting urban agriculture as part of the City's Climate Action Plan (CAP), setting a goal of "building a more complete and sustainable local food production and distribution system" (City of Berkeley 2018). What this goal entails in terms of social justice, equity, and available city resources to truly facilitate and protect spaces of urban food production remains unclear, but presents a policy opportunity.

One stakeholder suggested considering urban farms as museums, providing essential cultural and educational offerings to city residents (in addition to the important but relatively small total percentage of food delivered from urban farms to food insecure urban residents). The quality of the food (local, organic) and the value of the education, health, and community building, are strong arguments for including urban farms in an urban-agroecological framework for city planning and efforts to improve CFS.

The diversity of land access agreements and labor sources used by urban farmers in the East Bay underscores equity considerations in urban agroecological transitions. Farms rely heavily on donated land and volunteer and citizen labor. Even 50% of the for-profit enterprises reported relying on volunteer labor, speaking to both the precarious economics of running an economically viable for-profit food production business in the city, *and* the interest among young people and aspiring farmers in gaining agroecological cultivation skills through arrangements where they donate their labor free of charge. Volunteer labor substitutes for revenue to a certain degree, allowing farms to exist and distribute food informally without needing to generate much revenue or provide many jobs. In the UA literature, reliance on volunteer labor comes under criticism for being a product of the "neoliberal city," where responsibility for action falls to the individual rather than the state, and the equity concerns around *who* is able to volunteer their time are problematized (Biewener 2016). By reporting the common use of volunteers on East Bay urban farms, we do not seek to promote or valorize this practice, but rather recognize it as a necessary interim step occurring in our study context in the absence of dramatic local government intervention or radical reforms to address community food insecurity: those who are willing and able are participating through civic engagement in urban farms to produce, harvest and distribute healthy food to those in need. Many volunteers are retired or recent graduates, seeking opportunities to contribute meaningfully to their communities. The volunteers we have communicated with generally report positive experiences and enjoyment from their time digging in the soil.

Despite this, it is vital to acknowledge that the goals of food sovereignty underlying agroecology, especially the Nyéléni declaration, imply that food producers need to be able to earn a living to secure other basic needs, farm revenue is needed to sustain operations, and community members need to be able to pay. However, in cities where wages are stagnating relative to the cost of living and the right to remain is under threat to rising property values and rents (California's recently passed state-wide rent control law notwithstanding), affordability of food impacts growers and consumers alike. The critique in the literature against charity in the food system is that the dependence on charitable donations in the food space are a patch for the destructive neoliberal state, which has shifted the burden of social well-being onto the nonprofit sector. Heynen, critiquing the depoliticization of hunger and poverty through charity, asserts that "[c]harity, however well intentioned, has become the means by which the welfare state was successfully rolled back" (Heynen 2010). At the same time, in exploring the radical democratic politics of groups like Food-Not-Bombs, Heynen describes the kind of anarchist philosophy of mutual aid and cooperativism through food sharing that we see in the East Bay agroecosystem. Farms are not just distributing food to the hungry in hidden basements or exploiting free labor, but engaging in highly visible work, inviting those who visit or consume farm outputs to work, cook, learn, teach, share and get political. The reality is that growing food in cities has particular challenges, increasing the costs of farming on top of issues already outlined regarding the cost of land and labor (including soil remediation and challenges to distribution). We find that the importance of donated money and time to further the anti-hunger and advocacy efforts of farms is not counter to the transformational goals of AE broadly or UAE in particular.

In this way, we seek to nuance the premise that volunteer labor is universally problematic and counter-productive to radical food system reform efforts, aligning instead with some urban agroecological scholarship that argues for improved work-life balance through living wage jobs that afford more people opportunities to pursue hobbies and interests and volunteer their time supporting community efforts that align with their values (Pimbert 2017). Pimbert outlines three dimensions of urban agroecological transformation that are needed, including economic, with new forms of organization and relocalized wealth production as well as "creation of free time for citizens to shape and re-govern urban spaces" (Pimbert 2017). Volunteerism has a place in a transformed, equitable, environmentally sustainable local food system, although reliance on it as the primary source of labor is undesirable.

Our findings around labor in particular stand in contrast to the often-referenced benefit of urban agriculture as a job creation tool (USDA 2018; Vitiello & Wolf-Powers 2014; Pudup 2008). At least in the current political economic landscape of the East Bay, urban farms do not generate enough economic revenue or city investment in order to hire many full time positions; this remains a goal of many operations and opportunity for policy intervention, especially with respect to enhancing the resilience of urban agroecosystems to economic disturbance.

<u>Ending hunger and promoting equitable access to healthy, culturally appropriate food:</u> Farms in our case study display a strong focus on reducing hunger and promoting food equity, namely through culturally appropriate diets, and the emphasis on human and social values. Due to the plethora of produce going home with volunteers, circulating at neighborhood crop swaps, and gleaned or harvested by community members that is not weighed and tracked before it is consumed, it is understandably difficult to quantify the "food security" impacts of urban agriculture (see Siegner, Sowerwine and Acey 2018). While food security may be difficult to quantify, it is nevertheless being addressed by urban farms in unique ways (when compared to other citywide food security initiatives). In school gardens, for example, produce that is not used for classroom cooking demonstrations sometimes goes home with students or families excited to find culturally relevant crops growing in their neighborhood.

Supporting healthy, diversified and culturally appropriate diets are an important element of agroecology. The diversity and quality of produce grown, especially when it is an item that might not otherwise be available to a family in a "food desert," contribute greatly to the value produced on urban farms. One farmer interviewed described how one school garden site serves students from Hispanic, African American, Middle Eastern, Asian, and Eastern European families. The garden teacher spoke about the diversity of crops relevant to various cultural food traditions; for example, the chayote plants were of particular interest to Latinx students excited to bring them home to their mothers, while African American students eagerly collected bunches of collards, and Middle Eastern mothers came to the garden in person to collect fava beans and figs. In this way, urban agroecology contributes to food security and nutrition as well as biodiversity. It also serves to reaffirm cultural identity and a sense of place for immigrant and refugee families.

Agroecology places a strong emphasis on human and social values, such as dignity, equity, inclusion and justice contributing to improved livelihoods of [urban] communities (FAO: element 9). Our study demonstrated that the majority of farm respondents placed food security, education, and environmental sustainability above profit, sales and yield. Forty percent of respondents self-identified as "Educational" farms, and most others offer educational workshops and demonstrations as part of their focus on horizontal knowledge-sharing. Agroecology seeks to address gender inequalities by creating opportunities for women. The majority of our study respondents were also women. As a grassroots movement, urban agroecology can empower women to become their own agents of change.

Towards Urban Agroecology in the US: Implications for Policy: Our results suggest the opportunity to reconceptualize and refocus the urban food policy discussion in U.S. cities around urban agriculture in a way that includes and values their social, educational, and cultural services. Urban farms are recreational and cultural heritage sites bearing comparison to public parks and museums, while also producing invaluable healthy food in areas that most need it. They provide important respite, social connection, and stress reduction to urban residents, often particularly in need of peaceful spaces. In the words of one farmer, "Urban farms can be havens of peace, health, and community, but it *requires heavy involvement and advocacy from those communities* for the long term in order to be successful" (emphasis added).

Agroecology calls for responsible and effective governance to support the transition to just, equitable and sustainable food and farming systems. In an urban environment, this requires the creation of enabling policies that ensure equitable land access and producer control over access to land, especially among the more vulnerable and historically marginalized populations. Land access is expressed most frequently as an obstacle to scaling urban food production by survey respondents, and it is certainly more of a challenge for lower-income and minority groups interested in cultivating their own "commons" (Bollier 2014). There are examples among our East Bay survey respondents of collective governance at the farm and community level, such as one farm site which is owned cooperatively by three non-profit organizations that collectively serve minority and formerly incarcerated populations, aspiring beginning farmers, and the local community through a cooperative goat dairy, fruit tree nursery, and annual vegetable production plots. City and county governance bodies have an opportunity to strengthen the resilience of urban agriculture operations and opportunities for farmer collaboration by providing subsidies and incentives for social and ecosystem services. City-level efforts to compensate or recognize farmers for ecosystem services such as soil remediation and carbon sequestration, for example, are not yet realized. Further examples of responsible governance from our data include recommendations for public procurement programs to source food from aggregated urban produce (a recommendation that would be enabled by a regional food hub).

Our respondents are engaged in circular and solidarity economies, key features of agroecology, including bartering, sharing, and exchanging resources and produce with those in their social networks. They are also interested in collaborating in a localized effort to strengthen the link between producers and consumers by aggregating produce and sharing distribution (92% interest in sharing trucks or distribution systems). As cities work to fulfill their role in providing basic services to citizens, farmers are pointing out an important opportunity to provide refrigerated transportation, storage, and organizational infrastructure to transfer all possible produce grown on urban farms to the best distribution sites. Communication platforms, transport systems, and streamlined procurement in this arena following from other regional "food hub" models could improve the landscape for urban food distribution dramatically (see Berti and Mulligan 2016; Cleveland et al. 2014; and Cooper 2018).

All urban farm respondents are also engaged in closed-loop waste cycles: through composting all farm waste onsite and collecting food scraps from local businesses, farms are involved in a process of regeneration, from food debris to soil. The activities of urban farms fall naturally under definitions and descriptions of agroecology. Through extending the UAE framework from farms to urban policy and planning conversations, more efficient pathways for addressing food insecurity in part through strategic centers of urban production and distribution can emerge in cities of the East Bay and elsewhere in the United States.

Finally, agroecology relies on the co-creation and sharing of knowledge. Top-down models of food system transformation have had little success. Urban planners have an opportunity to address food insecurity and other urban food system challenges including production, consumption, waste management and recycling by co-creating solutions with urban farmers through participatory processes and investing in community-led solutions. In our systematic review of the literature on whether urban agriculture improves urban food security, we found three key factors mediating the effect of UA on food security: the economic realities of achieving an economically viable urban farm, the role of city policy and planning, and the importance of civic engagement in the urban food system (Siegner et al. 2018). A radical transformation toward a more equitable, sustainable and just urban food system will require more responsible governance and investment in UA as a public good, that is driven by active community engagement and advocacy.

3.10.1 Concluding remarks

We believe that urban agroecology principles provide an effective framework to capture the multiple ecological, social, economic and political dimensions of urban farming, beyond yield and profits, enabling those seeking transformative food systems change in the U.S. in the U.S. a common language and opportunity to measure and communicate more clearly the multiple benefits worthy of public investment. Framing this work as urban agroecology values the knowledge creation, community building, and human well-being that are also products of urban food initiatives. Our data illustrates how urban food sites are spaces of vibrant civic engagement and food literacy development yet remain undervalued by city planners and under constant threat of conversion as well as pressures of gentrification. With the majority of operations in our study functioning as non-profits, it is questionable whether many urban farms would actually be considered a true “agricultural” operation per the USDA definition as a majority of farms earn less than $1,000 in sales annually. As such, they are largely ineligible to apply for funding or loans from many of the federal and state agencies or granting programs such as the Farm Service Agency or NRCS.

The idea that the UAE framework can illuminate multiple and often hidden socio-political dimensions of urban food production sites is powerful. For example, over 75% of urban farming sites in our study came into being for a multitude of reasons: including re-establishing justice and dignity into historically neglected and marginalized urban communities, fighting poverty, resisting the environmentally extractive, exploitative, racist, and obesity-inducing industrial farming system, reclaiming the ability to be self-sufficient and work with your hands, and re-educating society about the physical and emotional value of cultivating the Earth. Urban farmers aspire to many things: affirming a human right to healthy food, a food literate civil society, land tenure arrangements that favor socially beneficial rather than profit-maximizing land uses, and alternative forms of exchange and value creation outside the capitalist political economy. The term “agroecology” locates these values in a historical network of similar efforts to transform the global food system along socially just and ecologically resilient lines.

Reframing UA through the lens of UAE can ultimately help U.S. policy makers and city planners better understand and support urban agroecological endeavors, and provide researchers, urban citizens and urban food producers a more inclusive mode of inquiry that can lead to transformative food system change, taking care not to dismantle, invalidate, or eliminate the revolutionary, anti-oppression elements through overly prescriptive "policy solutions."

When it comes to researching, documenting, and advancing transitions to sustainable food systems through agroecology, the urban context is an important one to consider, given the growing percentage of the global population living in cities. We acknowledge Gliessman's call for applications of his "5 levels of food systems change," showing in our data how East Bay urban farmers are endeavoring to scale up to Level 5: "build a new global food system, based on equity, participation, democracy, and justice, that is not only sustainable but helps restore and protect earth's life support systems upon which we all depend" (Gliessman 2016). We encourage future engaged scholarship in the U.S. that employs a UAE framework to ask and answer important remaining questions about the transition to sustainable food systems, in partnership with urban farmers, around valuation, preservation, and connectivity of diversified food production sites in the modern city.

CHAPTER 4: EDUCATION: EXPERIENTIAL FOOD AND CLIMATE CHANGE CURRICULA ON FARMS, IN SCHOOL GARDENS, AND IN HUMANITIES CLASSROOMS[19]

"With the planet facing the dire consequences of climate change and a global effort underway to reduce emissions and create a sustainable future for new generations, the question must be asked: How do we include the environment and sustainable development in our education system?" ~James Ellsmoor, Founder, Virtual Island Summit

This chapter presents two examples of climate change education outside of the science classroom. Building on climate change education research identifying, validating, and applying "best practices" for developing student climate literacy and improving climate education across U.S. K-12 classrooms, the first example evaluates a year-long climate change curriculum in a 6th grade humanities context. This example develops and presents an evaluation methodology for climate literacy, drawing on a student climate literacy survey tool, teacher interviews, and classroom observations. The first example leads to the hypothesis that CCE is most effective when it is experiential and action-oriented. The second example tests this hypothesis by looking at a case of experiential CCE integrated into school garden classrooms. It uses a similar methodology to evaluate a climate change curriculum with a food-focused lens, exploring impacts on student learning and behavior. Findings indicate promising outcomes and improvements to student climate literacy. Tying in with the food and climate change nexus that unifies this dissertation, the second example concludes with recommendations for scaling an on-farm, food-focused form of climate education for a K-12 audience.

4.1 INTRODUCTION TO EXAMPLE 1: CLIMATE CHANGE IN THE HUMANITIES CLASSROOM

The realities of climate change, both already experienced and forecast for the future, make teaching young people about the causes, consequences and solutions to climate change a national imperative for public and private education. Climate mitigating action is needed at all levels, from international to individual. Current levels of awareness and knowledge about climate change are "insufficient in leading to effective behavioral change" (Wolf and Moser 2011). Leaders in climate change education argue that "based on carefully developed evidence, the emissions gap cannot be closed without also closing the education gap—that is, the gap between the science and society's understanding of climate change, the threats it poses, and the energy transition it demands" (Niepold et al. 2018). Effective climate change education (CCE) practices are badly needed to close the gap, as authors go on to state, "education for action requires more than scientific literacy; it must integrate concepts and dynamics across disciplines and in ways that address affective, social, and cultural forces—a challenge that can be met through effective and evidence based climate change education" (Niepold et al. 2018).

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[19] The two examples of climate education in this chapter are based off of previously published works in *Energy Research and Social Science* (see Siegner 2018) and *Environmental Education Research* (see Siegner and Stapert 2019). The paper co-authored with Natalie Stapert is used with her permission.

Many organizations and research institutions are already committed to this mission, and are producing curriculum, resources, articles, online courses, and evaluations to strengthen the movement behind youth climate education and prepare teachers to introduce climate change content in the classroom (e.g. Western Washington University Facing the Future; North Carolina State University Environmental Education lab; Climate Literacy and Energy Awareness Network- CLEAN; NOAA Climate Education Office; Climate Generation: A Will Steger Legacy; Maryland and Delaware Climate Change Education Assessment and Research- MADE CLEAR; Arizona State University School of Sustainability; National Geographic). However, evidence suggests that climate education in the United States is still a work in progress, and that education in K-12 schools has not been successful on a national scale in clearly communicating the scientific consensus around anthropogenic climate change (Plutzer et al. 2016; Kuppa 2018). Plutzer's (2016) national study is titled "Mixed Messages," highlighting the problem that many science teachers are presenting "two sides" to a problem that is already resolved in the scientific community.

While science education has thus far been the most common channel through which to deliver and research climate change education (CCE), much scholarship emphasizes that CCE should be holistic and included in cross-curricular projects (see Schreiner, Henriksen and Hansen 2005; Climate Generation 2018). However, evidence of extended practice of holistic CCE is lacking. This study takes a "research into practice" approach, examining a yearlong effort to teach climate change through a humanities framework with integration between humanities and science curricula. Humanities is the study of the strengths and challenges of human society through literature, art, history, geography, civics, and economics. Applying the humanities framework to climate education builds on recommendations to bring a human face to climate education via storytelling, narrative, and other strategies in order to increase engagement and hope rather than provoke negative, detached emotional reactions (Wolf and Moser 2011; Nisbet 2009; Moser 2007; Westerhoff and Robinson 2013; Somerville & Hassol 2011).

This study evaluates an experiment in humanities-focused CCE for middle school students, investigating the climate curriculum pilot in the 6th grade of a small independent school located in NW Washington, D.C. It seeks to answer the research questions:

1) What are the impacts on 6th grade students and teachers of implementing a CCE curriculum over the course of an entire academic year focused in the Humanities classroom?
2) What administrative structures are conducive to adopting an integrated, holistic climate change curriculum?

4.2 Literature Review

A succinct summary of the past decade of CCE research appears in a New York Times op-ed in conjunction with the news around the UN Climate Action week happening in September 2019. The article is co-signed by leaders in the climate education field, and authored by Mark McCaffrey who leads the Climate Education, Communication and Outreach Stakeholders Community, an international group formed in 2016 and endorsed by the UN Climate Change Secretariat. The article lays out seven best practices for developing climate literacy in schools around the world: 1) Make it local, and global, 2) Make it relevant, 3) Make it hopeful, 4) Make it human, 5) Make it pervasive, 6) Make it persuasive, and 7) Make it integrated. The article concludes by stating,

> Climate literacy for action must be deployed across society and at every scale, from the global and national to the community, household, and ultimately individual level, where it will lead to informed climate action helping reduce emissions, cutting food waste, supporting regenerative agriculture and renewable energy alternatives, and preparing our youth for tomorrow's workforce. (McCaffrey 2019).

Several of these best practices for developing climate literacy are further described in the sections below.

4*.2.1 Effective CCE Strategies*

4*.2.1.1. Incorporate more than scientific evidence*- According to a recently published literature review on effective climate change education strategies, it is important to equip students with knowledge that is personally relevant and meaningful (Monroe et al. 2017). Approaching climate education through social studies and language arts promotes student engagement, climate literacy, and action, and highlights the human connection to climate change (Climate Generation 2018). According to a recent review of the climate communications literature by Susanne Moser, transitioning from awareness and concern into action remains a persistent challenge for the U.S. population as a whole (Moser 2016). The information-deficit model, which presumes that merely providing information will lead to desired behavior changes, has been debunked and critiqued by several CCE scholars (Wynes and Nicolas 2017; Wolf and Moser 2011) who argue that narrative frames, trusted messengers, and experiential learning pedagogy are required to motivate effective climate action (Nisbet 2009; Siegner 2018).

4*.2.1.2. Use local, real world contexts*- Integrating local and global "real world contexts" emerges as an important CCE strategy. A recent study highlights the use of the World Climate Simulation tool developed by Climate Interactive as effective in mobilizing engagement and intentions to action. Participants simulate real UN climate negotiations by representing a particular country, observing how their intended emissions reduction pledges affect global temperature, and negotiating with other "countries" to achieve temperature stabilization below 2^{o}C. Gains in knowledge, engagement, and desire to learn and do more about climate change were statistically significant, across the political spectrum (Rooney-Varga et al. 2018). This simulation integrates local decision-makers into a global process, the international UN conferences on climate change. Ideally outcomes identified by these global dialogues will then be implemented locally, at the community scale: recent research has identified a "sweet spot" for collective action and impact on climate issues as being between the "community" and "urban" scales, or 10,000-100,000 people (Bhomik et al. 2018). Schools are advised to plug into their local community to connect classroom CCE to climate action in their backyards.

4*.2.1.3. Incorporate new best practices from emerging CCE literature*- As this is a rapidly evolving field, there is a need for coordination and partnership between CCE researchers and practitioners, such that research can be more easily translated and adopted in the classroom. Further study at the intersection of research and practice is needed to investigate the efficacy of various climate education strategies as a vehicle for translating knowledge into action. Additional researcher-practitioner publications can improve the information transmission process between the theory and the classroom.

Regarding CCE evaluation, researchers seeking to measure impact of CCE interventions have developed measures and principles of climate "literacy," comprising knowledge, attitude, and engagement dimensions, to both qualitatively and quantitatively describe student outcomes

(Siegner 2018; CLEAN; NOAA 2006). Replication and consistency are needed to strengthen the comparability across contexts of various climate literacy assessments.

4.*2.1.4. Incorporate best practices into curriculum with associated PD*- There remains a lag in implementing findings from climate communications into the educational context of K-12 schools via teacher professional development (PD). Drewes, Henderson and Mouza (2018) report on the effects of a yearlong climate education PD for science teachers (the "Climate Academy"), tracing effects of participation into teaching practice in one particular classroom and suggesting room for improvements in CCE PDs (Drewes et al. 2018). Effective PD draws on content knowledge, proximity to practice, and context conceptualization, incorporating local examples, student/teacher emotional responses, and opportunities for positive impact in the local community (Drewes et al. 2018; Luft and Hewson 2014; Ojala 2012; Busch 2016). As Drewes et al. looks at only one classroom, deeper and larger-*n* studies are required to investigate and guide scaled-up CCE PDs.

Given that most of the literature focuses on PD opportunities for science educators, it is a unique facet of this study to consider CCE and PD opportunities for social studies and humanities educators. Based on curriculum evaluation data reported here, the school hosted a CCE PD for humanities educators nationwide in August 2019, which is evaluated internally by curriculum development partner and PD co-host Climate Generation: A Will Steger Legacy.

4.2.2 The promise of the humanities curriculum

Approaching CCE from a purely science educational framework risks overlooking the necessary economic, social, and behavioral adaptation and mitigation strategies human societies could choose to adopt. The humanities context allows for the full exploration of the anthropocentric nature of climate change, from information to human actors. What conditions in our history, politics, and economies led to the climate changes that people currently experience? How might these challenges be addressed through current or future social systems? What are the ethics of acting or not acting on climate change? The social studies inquiry arc, advanced by the National Council of Social Studies in its document, *The C3 Framework for Social Studies State Standards*, writes:

> Now more than ever, students need the intellectual power to recognize societal problems; ask good questions and develop robust investigations into them; consider possible solutions and consequences; separate evidence-based claims from parochial opinions; and communicate and **act upon what they learned**. (National Council of Social Studies 2017, emphasis added)

Humanities studies are central to creating an educated citizenry prepared for leadership in mitigating and reversing climate change. The humanities inherently incorporates real world contexts, social and political histories, and opportunities for human engagement between students and their surrounding community.

The humanities furthermore offer a unique opportunity to understand and address the bifurcated public response to climate change. According to the Yale Project on Climate Change Communication (YPCCC)'s Six Americas study, the American public response to climate change can be classified into six groups along a spectrum ranging from "Dismissive" to "Alarmed." As of December 2018, 9% of the public is "dismissive," and 29% are "alarmed," an 8-point increase since March (Leiserowitz et al. 2018). In order to channel the energies of this growing “alarmed” population sector in a productive, effective direction, investing in improved youth education, communication and engagement, fostering a greater willingness to take action, could prove an important leverage point (Niepold, Scowcroft and Gingras 2017). Several scholars have initiated research investigations into the Intergenerational Learning (IGL) that occurs as children bring home CCE topics learned in school to discuss with their parents, influencing climate literacy throughout the household and across generations.

Despite this potential, thus far no article published in the *Journal of Social Studies Education Research* takes up the issue of integrating CCE within social studies instruction, and a Google Scholar search for climate change and social studies education yields no relevant results. There are a small, growing number of practitioner-focused climate change and social studies education instructional and informational documents, published through channels such as the Climate Generation non-profit, and the National Council of Social Studies journals (geared towards educators) (Harris et al. 2016; Kumler and Vosburg-Bluem 2014), but publications in the academic literature are extremely limited. Thus, our research study contributes an important and missing perspective to the academic body of CCE literature.

4.3 Methods and School Context

4.3.1 School context and motivation

The Lowell School in Washington, D.C. is a small, progressive independent school that promotes active, collaborative learning with curricula that are “integrated across subjects, draw on powerful, relevant content and student interests, and support the development of internal motivation and a strong voice” (Lowell school website). As members of the staff became aware of the education “gap” in addressing climate change, based on participation in a workshop hosted by People’s Curriculum for the Earth, interest in incorporating CCE coincided with an opportunity to revise the middle school curriculum.

The curriculum developed for this pilot is the result of broad-based collaboration, involving internal as well as external partnerships. The Web of Support around the curriculum project is summarized in Figure 18. Each of the supporting elements played a crucial role in enabling the curriculum to come into being and serve as a platform for research, evaluation, and information-sharing.

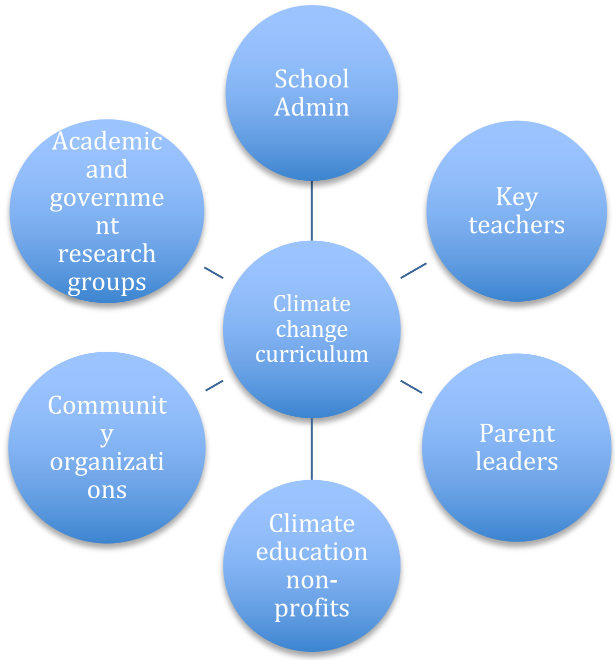

Figure 18- Curriculum Development Web of Support

The curriculum maps onto each trimester, with books, lessons, and topics falling within three themes: (1) Energy, (2) Movement, and (3) Collective Action (J. Totz, personal communication, June 1, 2018).

The Director of the Middle School acknowledges that Lowell's curriculum development process represents "pretty fast change" for adopting a new 6th grade curriculum, and that the new ideas were a leap of faith that required buy-in from key individuals who were able to bring others on board. Partnership with outside groups helped make this one-year curriculum development turnaround possible, as well as the school's status as an independent school (K. Yee, personal communication, May 18, 2018). There was a sense of urgency among the school leadership that climate change represents a crucial issue that the world is facing and therefore they should waste no time in delivering meaningful instruction on this topic to students.

4.3.2 Methods

Our study employs a mixed-methods case study design. We collected data from all relevant stakeholders and from various stages of the curriculum deployment: planning phase, implementation phase, and assessment/revision phase. Taken together, these data points create a holistic picture of the curriculum pilot, incorporating a variety of perspectives (both student and adult) and a mix of quantitative and qualitative data. Our aim is to uncover replicable, scalable processes in CCE curriculum development, implementation, and evaluation to guide other researchers and practitioners seeking to effectively develop and measure student climate literacy.

Consent for student participation in this research study, a partnership between Lowell School and the University of California, Berkeley, was obtained through school documentation from parents who sign blanket consent waivers upon enrollment for students to participate in any research study the school undertakes while their child is enrolled, and from the Lowell School Communications Director.

4.3.2.1 Data Collection- We evaluate the curriculum impact and enabling forces based off data from three main sources: 1) student surveys, 2) teacher/staff interviews, and 3) classroom observations. The student survey comprised questions on both climate change knowledge (9 multiple choice and 2 open response questions) and attitudes/engagement (6 questions, 4 of which are based off of the shortened YPCCC Six Americas survey). The survey was distributed to the 5th, 6th, 7th, and 8th grades, representing 116 students. The 6th grade results represent the "experimental" group in this semi-experimental design, while the 5th and 7th grade students represent "control" groups who did not receive the climate change curriculum focus in their humanities classes. The 8th grade students are used for additional comparative analysis as they study climate change for 12 weeks in science class, and are thus a form of comparison between science and social studies-based climate curriculum. Student surveys were anonymously collected without demographic information attached.

Interview subjects represented school staff (2), teachers (2) and the partner non-profit Climate Generation (1), for a total of 5 in-depth interviews of approximately 1 hour in length. By the nature of this study as a participatory research partnership, one of the interview subjects is also a co-author of this paper. Rather than muddying the waters of analysis or representing a conflict of interest, it is our belief and intention that co-authorship provides necessary clarity and depth of perspective on the curriculum pilot by partnering a climate education researcher with an educator interested in critically analyzing, improving, and disseminating a climate curriculum innovation. Interviews were semi-structured, and focused on the following topics: a) impacts of teaching climate change through humanities, b) student and parent responses to curriculum, c) process of developing curriculum and/or delivering instruction (strengths and challenges), and d) advice and recommendations for other schools.

The classrooms observations took place towards the end of the school year, in April, and notes were recorded for analysis by one co-author (Siegner). The other co-author (Stapert) contributed insights from her observations and experience working in the school over the course of the year in her interview (detailed further in the Results/Discussion sections below). Observational research methods bring critical insights and context to inform interpretation of results, revealing personal motivations and helping to uncover process dynamics leading to end results.

4.3.2.2 Data Analysis- Survey results were compared across grades and analyzed using Google Forms data analysis as well as basic statistical analyses. Google Forms is a commonly used educational technology, and thus using this method has the advantage of making the process easily replicable to teachers, schools, and education organizations seeking to gather their own data on similar interventions. Disentangling confounding variables and adjusting for student baseline academic performance and demographics are additional avenues for future research but were not the focus of this study.

Interviews were manually coded for themes and analyzed by type to understand differences in reaction between teachers vs. other adults involved in curriculum development and piloting. Interview themes inform next steps for Lowell as well as other schools seeking to implement climate change curriculum through a humanities focus, and guide researchers studying effective strategies and evolving trends in climate education. They reveal strategic improvements possible for the curriculum, as well as hypotheses for testing in larger CCE research explorations (ideally in both public and private schools).

4.4 RESULTS

4.4.1 Student Climate Literacy and Engagement

The climate literacy survey was administered to 30 5th graders, 36 6th graders, 27 7th graders, and 23 8th graders, for a total of 116 students. The 6th graders averaged 74.4% correct response on the nine multiple choice questions, while the 5th graders averaged 60.4% correct, 7th graders 69.5% correct, and 8th graders 74.8% correct (see Table 10). The 6th graders had higher correct response rates for five out of the nine MC questions; in the remaining four, the 7th grade had the highest response rate on two questions, and the 8th grade had the highest response rate in the other two. Asked about the global temperature rise limit specified at the United Nations Conference of the Parties (COP21) talks in Paris, the 6th graders outperformed their peers by the greatest margin, perhaps due to the focus on UN climate conferences leading up to a mock UN climate negotiations activity included in the curriculum (see Figure 19). In the open response questions regarding solutions for lowering CO_2 levels and mitigating climate change, the 6th grade students matched the 8th graders in terms of total number of responses across various categories (see Table 11), and were the only grade in which a student mentioned the single most impactful individual action to mitigate climate change: have fewer children (Wynes and Nicholas 2017). While the sample sizes are too small to merit statistical significance, there are other (non-statistical) conclusions of significance to be drawn from these results (see Discussion below).

Table 10. Climate Knowledge by Grade Level

	5th grade	**6th grade**	**7th grade**	**8th grade**
Average % Correct	60.4	74.4	69.5	74.8
# of students	30	36	27	23

Table 11. Climate Mitigation Strategies Identified
Coding of Student Open Responses

	5th Grade	6th Grade	7th Grade	8th Grade
Have less children	0	1	0	0
Education	0	1	0	2
Solar/Wind	12	19	8	17
Planting Trees	7	14	14	14
EVs/Transportation	12	19	16	23
Food/Farming	2	9	4	8

Total # of responses	**33**	**63**	**42**	**64**

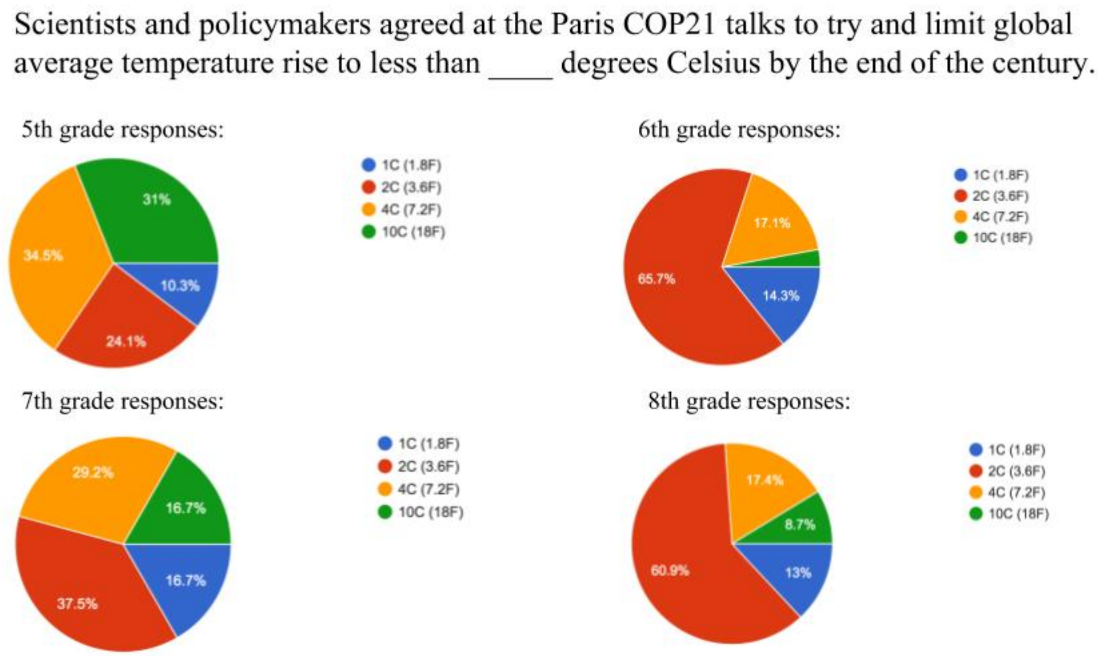

Figure 19- Response to Temperature Rise Limit Question by Grade Level

The attitude and engagement questions showed that the 8th graders had the highest levels of concern about climate change and its impacts on future generations, according to the first four questions, which were borrowed from the YPCCC shortened Six Americas Survey (SASSY). On the other two engagement questions, asking how often students had looked up information on climate change and talked to friends/family about it in the past year, the 6th grade students had the highest response rates. Responses to attitude and engagement questions are summarized in Table 12.

Table 12. Responses to Attitude/Engagement Questions by Grade

	5th Grade	6th Grade	7th Grade	8th Grade
How important is GW to you personally (Extremely/Very)*	65.5%	60%	56%	72.8%
How worried are you about GW personally (Very)	41.4%	44.4%	44%	50%
How much do you think GW will harm you personally (A great deal)	27.6%	16.7%	16.7%	13.6%

How much do you think GW will harm future generations (A great deal)	72.4%	77.1%	54.2%	81.8%
*Looked up info on CC** that you haven't learned in school in the past year (Weekly/monthly)*	17.2%	47.2%	16%	27.3%
Talked to friends/family about CC in the past year (Every day/weekly)	21.6%	38.9%	15.8%	18.1%

GW = Global Warming **CC = Climate Change

4.4.2 Teacher/Staff Interview Themes

Key themes from the interviews as a whole include middle school readiness for climate education, positive parental response, importance of partnerships, need for community action projects, developing a stronger solutions focus, further integration between science and humanities curriculum, and teacher preparation/professional development. Relating back to the research questions, they are presented here as they relate to student impacts and enabling structures for developing and implementing CCE through Humanities.

Administrative structure and enabling factors- The curriculum coordinator, who worked most closely on the development process along with Climate Generation staff, recognized the need from the beginning to build a wide platform of support for the idea from stakeholders both within and beyond the school. Several parents as well as staff, teachers, and external partners were present at the very first curriculum planning meetings. According to school staff, the reaction from parents has been overwhelmingly positive, and there is reported evidence of students discussing climate change with their parents. In the Director's words, "any pushback we were expecting has not happened," (K. Yee, Personal Communication, May 18, 2018). Parental support forms a key piece of the enabling environment for implementing CCE. The conversation has spread among parents at the whole school, who are aware of what is going on, and are motivated to keep their students at Lowell because of the new curriculum focus. It is additionally used as a recruitment tool to attract new families-- 2018/2019 6th grade recruitment gains are related to the new curriculum, according to staff. This reinforces administrative support to devote the resources and time to continue and improve the curriculum (N. Stapert, Personal Communication, May 7 2018).

Student outcomes- The curriculum coordinator summarized the first year implementation as follows: "Students learned how climate change affects a variety of people around the world, and how different people are responding to it. They read fiction and non-fiction texts featuring climate change and studied the interaction of geography, civics, and economics with climate change. Next year we are hoping to add a substantial service-learning aspect to the course, as well" (N. Stapert, Personal Communication, August 1, 2018).

When asked if middle schoolers are "ready" to learn about climate change, addressing a common concern among educators about an age threshold for talking about a topic as overwhelming as climate change, all respondents answered in the affirmative. In the words of one teacher, students learn about the Holocaust and slavery in middle school, so they're already dealing with emotionally charged content. One 6th grade teacher initially felt inclined to avoid the topic due to "gloom and doom" connotations and possible negative emotional responses, preferring to focus instead on developing a love of nature and the outdoors among students. However, he reports having his mind changed by the curriculum pilot experience, and notes that his skepticism about the climate fiction (or "cli-fi") novel in particular proved unwarranted. The students had incredibly positive responses to the cli-fi novel chronicling a girl and her family's flight from their homeland as climate refugees and struggle to start a new life. Students felt catalyzed to take action: "The Cli-fi novel was groundbreaking for me. The kids really enjoyed it. It's a weird way for doom and gloom to be exposed to them, but yet their reaction is incredibly surprising, I thought they'd turn off, but it almost seems motivating and inspiring them to learn more" (L. Kelly, Personal Communication, May 18, 2018).

The Director of the Middle School brought up several noteworthy outcomes from the first year not captured in the student climate surveys. From the school's internal standardized testing, he noticed a dramatic improvement in the 6th graders' reading comprehension scores. Students increased by almost two Standard Deviations from their scores last year, an unusually high rate of increase, with top students maintaining their performance and the bottom third reaching grade level standards (from below grade level performance in 5th grade). According to the director,

> Our kids know how to read and draw inferences from non-fiction texts. You see natural progress year to year, but don't often see close to 2 SDs in data year to year. I can't completely attribute that to new curriculum, I need more data, but it certainly prompts the hypothesis that it might be the curriculum. They are constantly discussing non-fiction texts in Dave's class this year. It's building skill in a more meaningful way because they are more engaged. This is something I'll be tracking closely in the coming years and looking for improvements in writing skills as well in the 7th grade testing cycle (K. Yee, Personal Communication, May 18, 2018).

The Middle School Director concludes his interview with a call to action to other schools to "be courageous and take risks… Why are we denying this? It's everywhere. [Climate change] needs to be addressed squarely in Middle School curriculum, giving students a chance to apply it in higher grades" (ibid). His recommended improvements, for Lowell and elsewhere, include carrying the curriculum theme forward into the later middle school grades, including 7th and 8th grade science classrooms, and making climate change a focus for 8th grade independent projects.

<u>Areas for growth-</u> One key growth point identified in several interviews was the need to expand and improve the solutions focus within the curriculum and provide opportunities for students to take meaningful action locally on climate mitigation options. For example, when students read "The Boy Who Harnessed the Wind," students build windmills in science class. During the focus on renewable energy, they could also do a community action project around solar incentive programs: Maryland has a program for homeowners to put solar on their roofs, and students could advocate for D.C. to adopt a similar program as the same publicly owned utility covers both jurisdictions. Another idea brought up by staff is to change the end-of-year field trip from New York City to an island in the Chesapeake Bay threatened with disappearance due to sea level rise. The solutions piece is the most complex part to develop, as the content must be laid down first and authentic solutions built on top of that. This is a clear area of focus for future years (N. Stapert, Personal Communication, May 7, 2018).

Box 4.1 Teacher Interview Spotlight
Focusing on the teacher response themes brings up a mix of reactions to the curriculum, simultaneously categorizing the experience as fun/exciting and difficult/challenging. Both teachers highlighted the *Boy Who Harnessed the Wind* close reading and aligned windmill project as a key success of the year, as well as the Fossil Fuels Museum project on which they collaborated. In this futuristic museum simulation, students created and presented their exhibits to the Kindergarten class, explaining how society "used to" source energy from fossil fuels but now procures energy from alternative clean sources. These two activities should ideally inspire further integration opportunities on other topics and throughout the school year. In science, the teacher is considering a revision of the entire first unit to be about Energy and Environment, centering hands-on school greening projects. Speaking to student outcomes, the science teacher states, "the humanities focus is great...When environmental science is cross-curricular, it's much more meaningful… Doing it through humanities connects [students] to it much more. And taking more time to do [climate education] in humanities makes science lessons even better" (L. Kelly, Personal Communication, May 18, 2018).

4.4.3 Classroom Observations

Classroom observation notes were collected from visiting both 6th grade humanities classes in April 2018. During this visit, 6th grade students articulately expressed the difference between climate change and global warming, which they acknowledged they had not known previously. One student clearly explained the process of hydraulic fracturing in incredible detail, down to the underground wells with cement lining, injecting water at high velocity to release the oil stored in underground pores, producing a lot of wastewater and creating seismic activity (according to the teacher this was based on independent knowledge acquired at home; in this case, rather than teaching the student something new, the curriculum seemed to provide an opportunity to share her knowledge with the class in a relevant context). Students were generally excited to share what they had learned, and recounted memorable topics and projects of particular interest to them. This included the "CliMojis" art project, where they created personal Climate Emojis after reading a Washington Post article about a company designing climate change-based emojis, so that texters could communicate their frustrations and anxieties around climate change pictorially (Chiu 2018). The students read and discussed the article, and then designed their own climojis, synthesizing learning in a visual form. Other significant learning experiences reported were the Fossil Fuel Museum and learning about how bees will be impacted by climate change while reading a novel called *The Hour of the Bees*. When asked what students were hoping to do about climate change based on their newfound knowledge, students responded with ideas such as spreading awareness, creating more things from plant materials (biofuel, degradable plastics, food, etc), farming in a way that supports the environment, and putting more plants in the ground. Many students seemed to have clear ideas around how to take action and expressed feelings of hope and empowerment when describing their collective "climate solutions."

4.5 Discussion

As a whole, the Lowell middle school demonstrated much higher levels of knowledge and engagement around climate change than the average American teenager or adult. Based on a 2010 nationally representative survey of American teenagers, knowledge of climate science basic facts was found to be very low (below 50% correct for most questions asked; Leiserowitz et al 2011). 59% of American adults fall into the “Alarmed” or “Concerned” categories of the YPCCC Six Americas spectrum as of December 2018 (Maibach et al. 2018) compared to 82% of Lowell middle school students. What remains a challenge both nationally and at Lowell is building optimism around our ability to solve climate change: only 8% of youth agreed that we can and will do something to mitigate climate change in a recent study (Feldman et al. 2010 cited in Busch, Henderson and Stevenson 2018), and a mere 5% of Lowell students indicated they believe their generation will solve climate change.

While acknowledging the receptive audience for implementing the curriculum, the results relating to increased student engagement, increased reading scores (for even the lowest-performing students) and favorable response to a humanities-focused climate curriculum are nevertheless significant and worth building on as an approach to middle school climate education. Further hypotheses are generated such as the claim that climate change as an engaging topic can help boost student performance in core academic disciplines (e.g. reading, math, science), requiring further testing via controlled experiments.

The time period between 6th and 8th grade is a significant youth development stage during which students develop capacity in knowledge retention and empathy and gain exposure to many new topics, and yet the 6th graders performed equal to or above the 8th graders on most climate knowledge and engagement questions. They shared information learned with families and friends more often than their 8th grade peers learning about climate change through science only, generating important hypotheses for CCE/IGL scholars (see Valdez et al. 2017).

Results and best practices from this case study should be applied intentionally to other classrooms and school contexts. The web of support (extending from parents to teachers and staff) is a crucial enabling factor as well as the participation of key influencers, which must be identified in other contexts. The Lowell School curriculum coordinator suggests several vehicles for integrating similar curricula into more structured, state-mandated public school subject matter: through choice of reading materials in civics classes, suggested options for student independent research projects, and current events classes at the high school level. She outlines three specific opportunities for incorporating climate education into social studies classrooms through tweaks to what is already happening, rather than major curriculum overhauls: 1) in elementary school states and regions studies, where studying the climate of the state or region is already an explicit objective, 2) middle school global geography classes, and 3) in high school current events classes. She sees these as opportunities to “lean into the climate change challenges and how people are addressing them in different contexts” (N. Stapert), while minimizing instructional tradeoffs. The Director concurs, adding, “for independent schools this change is very easy. But for public schools, there’s so much you can do with this curriculum too. If you have to teach about government, geography, or history you can use pieces of this [integrated into pre-existing units and curriculum mandates]” (K. Yee, Personal Communication, May 18, 2018).

Preparing teachers to be effective conduits of climate education is a crucial step in humanity’s response to climate change, as “teachers occupy a social role as cultural authority in traditional classroom contexts and are therefore differentially powerful actors in educational spaces” (Gore 1995 cited in Drewes et al. 2018). Teachers are important influencers of what “comes to matter” in the classroom based on their ability to mobilize and communicate their own knowledge effectively (Ball, Maguire and Braun 2012). A recent National Academies Board on Science Education report concludes that “ultimately, the ability of the elementary and secondary school systems to provide comprehensive climate literacy education will depend on the systematic availability of quality curriculum resources, impact of curriculum mandates such as state standards and assessment, and, importantly, the preparation of teachers" (Simmons 2011, emphasis added). The Lowell curriculum coordinator is keen to put these recommendations into practice, through co-facilitating a Summer Institute for Climate Education with Climate Generation at Lowell School in Summer 2019. The 3-day institute will be geared towards Humanities educators.

In order to scale up and improve existing CCE PD offerings, policy support and funding will be necessary, as well as additional CCE research focused on evaluating PD opportunities and how well they address the needs of both science educators and those from other disciplines. The opportunity to provide integrated Social Studies + STEM PD trainings around climate change is a key area for growth as more states consider adopting climate literacy and education policies.

Based on our findings that humanities-focused climate education shows promise in engaging students through narrative, storytelling, and local community projects, and building upon climate communications research that similarly emphasizes a storytelling approach, humanities CCE should be further implemented and investigated through comparative analyses and case studies in other locations that employ a similar climate literacy assessment methodology. This study will benefit greatly from replication particularly in public schools, which are more challenging environments in which to innovate on curriculum content, but more reflective of the U.S. student experience. The time for further study is ripe, with national polls indicating public opinion is strongly in favor of climate education, at 79% supporting the teaching of climate change in public schools (Marlon et al. 2018).

4.6 Applying CCE Curricula And Climate Literacy Assessment in the Field

Students receiving the humanities-focused climate curriculum exhibit academic gains in reading comprehension and enthusiasm for the curriculum content. Nonetheless, as seen above, the action/solutions focus can be strengthened by better incorporating authentic and meaningful student climate action projects in the local community. This emphasis on experiential learning may lead to even more effective outcomes as students become empowered to act on their climate concerns. This calls for additional partnerships and planning in order to implement, and may include field trips, hands-on schoolyard greening projects, contacting local elected officials, and developing community-school collaborations that allow for service-learning projects to have meaningful impacts.

Future studies should focus on the student action elements of CCE, and how to most effectively build the education into action pathway, as the "action" piece remains elusive and difficult to measure in many CCE curriculum studies and climate literacy assessments. Does experiential learning focused on action actually result in improved learning outcomes? To investigate this question, I next look at bringing climate education to school gardens and educational farms.

4.7 Food Systems and Climate Change Curriculum Evaluation

This second example of climate education assesses the efficacy of implementing an interdisciplinary, experiential food and climate change curriculum in school garden classrooms. Outcomes of interest include student climate literacy and teacher professional development. Questions of how to teach and research climate education are explored via a participatory teaching + research project with school gardens in Oakland, CA and Lopez Island, WA. Initial results show improvement in student learning and engagement as well as teacher preparation. Both qualitative and quantitative data are analyzed through student surveys, teacher interviews, and site observation; however, further qualitative methodologies to study *process* of climate and food literacy development are needed. Specifically, this example makes a case for new forms of assessment to capture the multiple dimensions of food and climate literacy including knowledge, engagement, and action/behavior change. It builds on existing climate, environmental, and food literacy research and provides insights for how food systems and climate research can better integrate with K-12 education development.

4.7.1. Background and Research Questions - Building off of expressed desires for implementing climate education in school garden classrooms (e.g. on Lopez Island and in Oakland Unified School District), this study examines problems of method in two dimensions: methods of delivering climate instruction, and methods of evaluating climate literacy. It is a case of experiential curriculum development and piloting in San Juan County, WA and Oakland, CA. Climate change communications, CCE, and food literacy literatures offer useful strategies for developing students into informed decision makers capable of addressing climate change in their communities (Moser & Dilling 2007; UNESCO 2010; NOAA; Klenk et al. 2015). Drawing on the existing bodies of scholarship, the curriculum features climate education activities in the school garden in order to evaluate whether this represents an effective experiential climate education strategy.

This study addresses the research questions: 1) What are best practices or effective strategies for delivering climate change curriculum that leads to increases in student climate literacy? 2) How do we currently measure and study climate literacy? And 3) What is the impact on teacher competency and student climate literacy of a 6-week experiential climate curriculum taught in school garden classrooms?

Experiential climate change education engages students in hands-on activities and projects that are solution-oriented alongside the presentation of climate science. This approach builds on the best practices of both experiential learning theory and climate change communications by incorporating personal action accompanied by reflection and fostering hope and positive engagement around a complex global issue. By making climate education experiential, it is more salient and actionable for students rather than paralyzing. A school garden is commonly identified by school and district leaders as an effective platform for experiential learning opportunities that also can boost academic performance, attendance, behavior, and student health (see Lieberman and Hoody 1998; Blair 2009; National Farm to School Network 2017). Garden educators often recognize the climate benefits of local food production, but this connection is seldom passed along to student gardeners. Thus, gardens were chosen as the context of study for implementing an experiential climate curriculum.

The pilot schools represent "early adopters" of climate-friendly schoolyards and climate change curriculum, which is not yet widespread in the U.S. (Plutzer et al. 2016; Golden and Francis 2014). I use a small sample size (four schools) to generate further hypotheses on what strategies work for bringing student beliefs, attitudes, and behaviors in line with well-defined actions/solutions for climate mitigation. The case studies are therefore an opportunity to learn from schools where climate education shifts are already underway, one in a rural agricultural setting and the other school district in a progressive urban environment known for food justice activism. Both contexts are examples of high community awareness of climate change (City of

Oakland 2012; Knuckles 2012): thus, if particular CCE strategies cannot succeed in these contexts, the chances for their widespread success are low.

Case 1: Signs of Positive Change. San Juan Islands, WA

The San Juan Islands are a national bellwether in the sustainable agriculture education field. They are the top-performing district in Washington state for farm to school activities according to the USDA annual Farm to School Census (USDA 2016). The school garden at the Lopez Island School is a thriving agro-ecological example of a ½ acre food production center that meets most of the fruit and vegetable needs of the school cafeteria, producing over 6,000 pounds of produce annually. However, in-school efforts on integrated energy and climate change education are a self-identified area for improvement. The Lopez school site became a pilot case for the food and climate curriculum based on results from a prior research study on the district's Farm to School program (described in Chapter 2). Through surveys and interviews with school leaders in spring 2016, I identified climate change curriculum intervention goals in collaboration with teachers, administrators, and students. Follow up focus groups provided the impetus for co-teaching a food and climate curriculum in collaboration with the garden teacher. In spring 2017, I implemented a curriculum pilot in the Lopez Island Sustainable Practices classroom for students in grades 8-10. The curriculum pilot was accompanied by pre- and post-surveys for student climate literacy, as well as a teacher interview to debrief the co-teaching model of instruction (discussed further below).

Case 2: Oakland Public Schools. Bringing Food and Climate to the Urban Context in CA.

Oakland Unified School District (OUSD) is a national leader in the school lunch reform movement. The district is working towards establishing school gardens at all schools, as well as a Central Kitchen and urban farm to provide centralized distribution of locally grown produce to school cafeterias. However, like the San Juan Islands, leadership in school food systems and local sourcing is not yet accompanied by corresponding leadership in climate change education. There is interest at the district and school level to incorporate climate change into school garden classrooms and more thoroughly across multiple school subjects, but preliminary action steps are just beginning. Partnerships with community groups and local universities are seen as a desirable and realistic way to incorporate climate change into both science and garden classrooms.

In consultation with the OUSD School Gardens Coordinator and the University of California Cooperative Extension (UCCE) Bay Area Urban Agriculture Advisor, I identified 3 schools for a climate change curriculum pilot in spring and fall 2017. The pilots were assessed with the same student survey and teacher interview guide used at the Lopez school.

Pre-implementation interviews with educators and students in the San Juan Islands and Oakland Unified School District show that there is a strong interest in incorporating climate change into school garden educational curriculum, accompanied by a need for training in order to do so effectively. Adults often recognize the climate change connection to their farm to school activities (in addition to health and nutrition benefits) but acknowledge that students are not yet taught about these connections. Adding to the education-action gap, teachers often do not feel qualified to teach students about climate change without being content experts themselves.

Preliminary program evaluations and discussion themes at National Farm to School conferences indicate that the education core element is lagging behind the other core Farm to School program elements: presence of school gardens and local procurement (USDA 2016;

National Farm to School Network). The lack of comprehensive or strategic integration of garden-based education into broader environmental and climate educational contexts leaves many garden educators searching for curriculum independently and not utilizing garden classroom time to its full potential; climate change is a glaring omission in all garden curricula and evaluative studies examined for this research project. Furthermore, integration of program evaluation methodologies and consistent tracking of farm to school activities remains a challenge for researchers and practitioners (Yoder et al. 2017; Joshi, Azuma & Feenstra 2008).

4.7.2. Curriculum Development, Content and Evaluation

Figure 20- Curriculum Development Process Diagram

Figure 20 summarizes the chain of activities relevant for this study, which addresses method in two dimensions: pedagogical method (how to teach) and evaluation method (how to assess/evaluate climate literacy). The methods for curriculum development followed processes common to teacher training programs, and incorporate best practices from both critical pedagogy and experiential learning theory. Critical and experiential pedagogy places the teacher(s) as designers of the educational experience, as coaches or facilitators, and students as leaders of their own learning. Both teachers and students have agency to ask and answer questions, and outcomes are necessarily more fluid and less predictable than pedagogy that lends itself to standardized test-taking. Importantly, critical pedagogy implies an embedded project of unearthing and subverting oppression (Freire 1970).

The curriculum content is the product of collaboration and feedback with education non-profits and partner teachers, following participatory action research principles. Initial ideas and activity outlines emerged following interviews and focus groups with school garden educators in the San Juan Islands in spring 2016, as well as conversations with Oakland garden educators in fall 2016. A key partner in the curriculum development process is the nationally recognized non-profit Climate Generation: A Will Steger Legacy, the source of the climate curriculum that was modified to provide a food/ag frame around the six-lesson structure. Food is a powerful frame through which to make the climate change problem more concrete and "close to home," as it implies both a social and essential daily activity. The garden, meanwhile, provides a useful metaphor for the complex global climate system. The curriculum directly connects climate science to community and local action in the garden, thus linking food and climate systems. This systems-thinking lens aligns with Next Generation Science Standards (NGSS), something that motivates teacher participation if their schools have adopted NGSS. Through local examples, garden activities and guest speakers, the curriculum connects students to other change makers and empowers them with agency to help build a more sustainable food system in their community. Students learn to think of climate change as more than "just" a science problem: it is a social problem requiring action and responsibility from all levels of society—individual to international.

Each of the six lessons involves students in activities that translate regenerative agriculture theory into practice (see Appendix for Curriculum Outline aligning each lesson to an objective and activity). The curriculum provides opportunities for students to learn scientific facts (engaging minds), share personal narratives (engaging hearts), and enact hands-on solutions to climate change via school gardens (engaging hands). Students learn about the carbon cycle and soil carbon sequestration while building compost piles. They learn about the negative effects of elevated CO_2 in the atmosphere globally and then help lower CO_2 locally through increasing plant photosynthetic activity. The pedagogical framework for the curriculum is inspired by Paolo Freire's critical pedagogy (Freire 1970) and other more current framings of a signature pedagogy for sustainable food systems education (Valley et al. 2017). Educators facilitate collective learning experiences that are often subversive in nature and seek to disrupt inequitable outcomes, both environmental and social.

Curriculum implementation followed a co-teaching model. The researcher-teacher partnership draws on complementary domains of expertise: content expertise from the researcher, and classroom management/student dynamic expertise from the teacher. Two symbiotic goals are addressed using co-teaching as an implementation method: 1) students learn climate change from a content expert, and 2) teachers increase knowledge and competence in climate change instruction, allowing future students to benefit from a better-trained instructor and serving as a form of professional development. Studies have shown repeatedly that the best way to improve student performance across a range of subjects is to boost teacher knowledge and competency (Pluzter et al. 2016; Guerriero 2017).

This type of participatory, co-teaching implementation inherently limits ability to statistically analyze a large, representative, or randomly generated dataset of students. It is grounded in social science theory of the qualitative, in-depth case study. Each school required slightly different implementation of the curriculum. In one case snow days canceled several co-teaching sessions, which then had to take place via Skype. Taken as a whole, these four cases shed light on important adjustments that can be made to tailor climate change education interventions to site-specific school needs. Pragmatically, meeting unique school needs is a prerequisite for implementing any non-mandatory education intervention in partnership with schools.

The study simultaneously investigates student responses to an experiential climate curriculum, *and* teacher responses to co-teaching as a form of professional development. The methods used for evaluating curriculum efficacy include 1) semi-structured teacher interviews, 2) student surveys (pre- and post- curriculum intervention), and 3) participant-site observation. Triangulation of these methods improves the validation of results. Deeper understanding can be gained from a small set of cases on CCE, and best practices can then be applied to a larger universe of schools.

More specific to each method, teacher interviews (1) followed a six-question interview guide and were semi-structured in nature. Preliminary student surveys (2) provide a baseline for student knowledge and engagement. Compared with post-intervention surveys, this allows basic statistical analysis to define the effect size in the sample population and whether it is significant. The survey assessment includes 10 knowledge-based questions on climate science and food systems applications, as well as 19 engagement questions asking opinion statements measured on Likert-type scales. This multi-faceted assessment of climate literacy recognizes that "knowledge about climate change can be divided into several general and overlapping categories: knowledge about how the climate system works; specific knowledge about the causes, consequences, and potential solutions to global warming; contextual knowledge placing human-caused global warming in historical and geographic perspective; and practical knowledge that enables individual and collective action" (Leiserowitz et al. 2011). The engagement questions adapt the Six Americas survey questions to capture students' change in engagement towards climate change following the curriculum intervention. Participant and site observation (3) over a six-week period captures important features of the school climate, both environmental and social, that help contextualize interpretation of results. The quality of the school garden, behavioral norms, and student informal interactions are all variables of interest for understanding other forms of data collection.

In climate literacy evaluations, it is important to understand student intention to take action and follow up to document concrete examples of students taking action, which goes beyond simple survey and interview protocols. Certainly, questions can be posed to students asking whether they feel more empowered to seek out their own additional knowledge and participate in climate actions, but ideally these questions can be followed up with evaluation tools documenting actual action outcomes. This was not possible in the contexts of study reported on below but should be a focus for future student climate literacy evaluations.

Results presented and discussed below are broadly relevant to climate change education interventions, with some insights as well into the value of food as an engaging entry point or frame for the climate education conversation.

4.7.3. Results/Discussion

Initial results from curriculum piloting (Spring 2017) demonstrate increases in both student knowledge and engagement with climate change. Climate literacy was assessed in a holistic sense, including student knowledge of appropriate individual and collective actions. As shown in Table 13, student climate change knowledge scores increased by 15 percentage points on average over the course of the six-lesson curriculum with a reduction in variance and statistical significance ($p < .001$). The largest gains were seen in Lopez and Oakland 2. Results are summarized in Tables 13 and 14 and broken down by question in Figures 21.

Table 13. Aggregate Climate Literacy Survey Results

	Pre Survey	**Post Survey**
Mean (% correct)	53	68
Variance	5.6	4.26

Table 14. Results by School

	Lopez	Oakland 1	Oakland 2	Oakland 3
Pre (% correct)	53	49	59	21
Post (% correct)	69	58	75	30

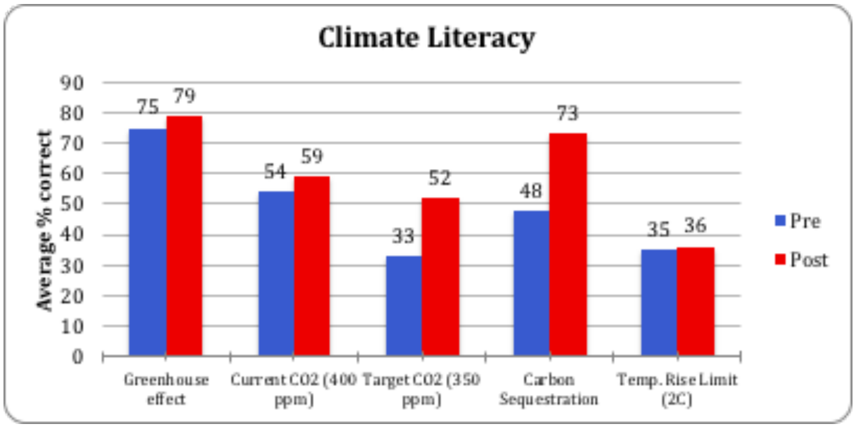

Figure 21- Climate Literacy Scores by Question

Attitude and engagement questions revealed higher levels of concern along the Six Americas spectrum than the national average. The first 10 questions were adapted almost directly from the Six Americas survey, with some modifications for student-friendly language. An additional nine questions were added dealing specifically with food systems, behavior and climate change. Based on the first 10 questions, students were categorized into the six segments from alarmed to dismissive, with almost all students falling in the top three categories (alarmed, concerned, and cautious). Students demonstrated an overall increase in engagement although this was difficult to measure with precision due to inconsistencies within individual student response patterns. A preliminary analysis (Figure 22) is valid for determining directional effect arrows and assessing whether pilot programs show promise, and thus were adequate for this evaluation. Precision could be added in future iterations by simplifying answer scales so they are consistent, and then quantifying student attitudes on a numerical basis. The survey was a bit long to hold student attention, and survey fatigue was a confounding variable in some cases. Work is underway by the Yale Project on Climate Change Communications to create a four-question survey version for teens (SASSY), which will be a valuable improvement for future studies.

Informal observations and conversations reveal a notable curiosity and interest among youth in learning more about climate change. A commonly expressed sentiment, especially at the outset of the curriculum intervention, is that climate change is an important issue that students feel they should know more about. This is mirrored in national statistics reporting that American teens recognize their limited understanding of climate change, and 70% say they would like to know more about the subject (Leiserowitz et al. 2011).

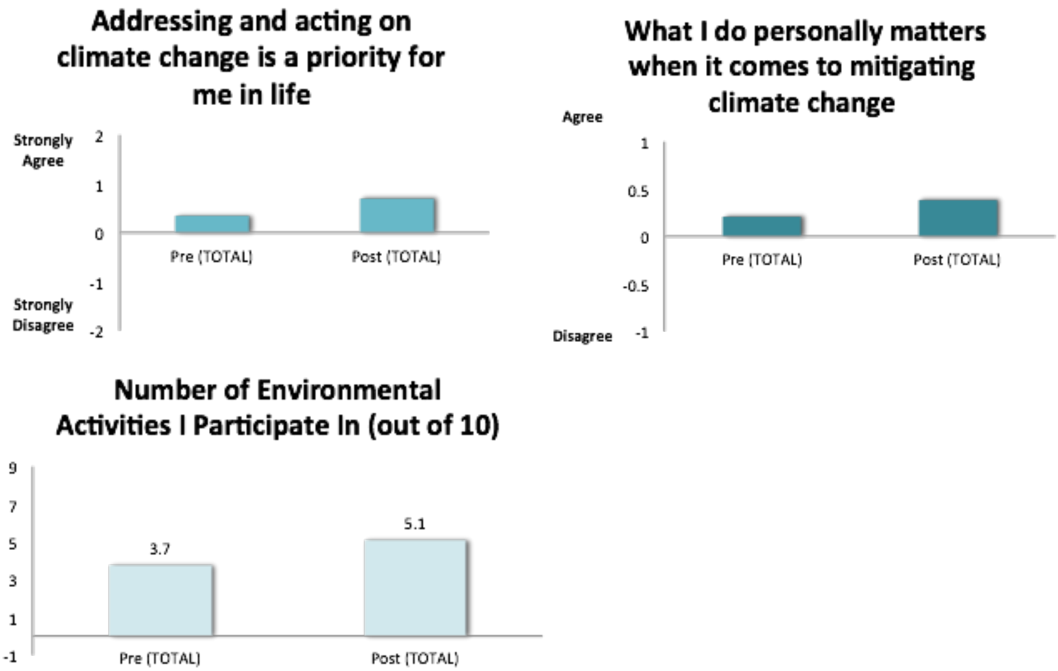

Figure 22- Student Environmental Attitude Responses

Post-intervention teacher interview themes revealed a widespread appreciation of co-teaching as a mechanism for delivering climate change instruction. All teachers interviewed expressed enthusiasm for having a content expert present to deliver instruction on climate, complementing the garden teachers' expertise in food-related topics, classroom management and student behavior. The positive response from teachers is important to contextualizing student results, as the more enthusiastic and knowledgeable teachers became about climate change connections in the school garden, the more engaging lessons became for students.Teachers were able to learn from the experience and expressed desire to replicate elements of the curriculum on their own in the future, thus meeting one of the process-specific goals of the research. Interviewees also revealed a common theme of searching for hope and action amidst the daunting reality of climate change; the garden and classroom were often identified as key arenas where hope and solution steps exist. Key quotes from interviews are highlighted in Table 15 below.

Table 15. Teacher Interview Responses

	Teacher Response		
Co-teaching model	*"One of the things I like about having co-teachers is that it just means more to [students], they listen better… and I learned from the experience and I can begin to weave it into what I do and teach."*	*"Having an expert in the classroom was amazing... I have an agriculture background and you have a science background so it worked well."*	*"Kids get really excited about having guest in class, cool idea to have a mini-unit with guest leader."*

Climate change instruction	*"A lot of climate change is out of control and scary for kids, but to teach while doing something positive [in the garden] helps balance that out."*	*"The garden system is a metaphor for the complexity of the climate system."*	*"Even when you're not harvesting food there's a reason for cultivating the earth: sequestering carbon. The actions they take as individuals contribute to our planetary health. When you are producing food, it's a double win-win."*
Challenges	*"Lectures would be impossible to do on my own; need videos or further guidance for independent teaching."*	*"Particularly for those in low income areas who are used to being disenfranchised, they don't see [climate change] as relevant to them... recognize it as a future thing, but inner city kids are dealing with things that are more relevant in the here and now."*	*"A big challenge is that the ways we contribute to climate change as a society are so ingrained... you're asking a lot of things that make life harder, especially for middle school kids; don't want to think about where their food comes from because they don't want to know the answer, and the bigger solutions are way out of their hands."*

These results, in particular the challenges highlighted by teachers, closely match national findings on climate change education. In a recent national review of science teachers, the first nationally representative study of science educators to focus on climate change, fewer than half of all teachers reported any formal coursework on climate change, yet over two thirds would like targeted professional development opportunities to allow them to dive in deeper to this complex and emotionally sensitive topic (Plutzer et al. 2016). It is well established that teachers are in need of professional development in order to teach an unfamiliar subject with confidence and competence, and several national leaders in climate education are addressing this (CLEAN 2018). Having a climate science "expert" in the classroom to co-teach a climate change curriculum for the first time is another promising form of PD explored here.

Partnerships (with local NGOs, universities, and community groups) emerged as a key feature enabling success of food and climate education in schools, mirroring the findings in example 1 above. Partner organizations and individuals are able to provide infrastructure support, outdoor learning environments, guest speakers to reinforce climate education units, and program evaluation assistance. Questions of how to scale impact via partnerships at the district or state level and education policy implications are discussed below.

Examining results by school context offers strategies for scaling this type of intervention in rural vs. urban school districts. Students at the Lopez school, with abundant local farm and forest resources to devote to furthering climate curricula endeavors, selected a biochar experiment as a class climate action project, and will be applying locally produced biochar to test plots in the school garden to compare with non-treated plots (observing effects on yield, plant health, and soil carbon levels), in partnership with the community. This community-school partnership adds to the body of successful climate change engagement strategies meriting replication, particularly other rural communities where local farmers might be interested in participating in farm to school programming at the school or district level.

Students in Oakland had more immediate food-security and job-related concerns that focused their attention on school gardening as a vehicle for meeting short-term goals (getting enough healthy food to eat, gaining job skills) rather than long-term goals (fighting climate change). Food insecurity is a widespread problem (62% of Oakland youth live in households receiving SNAP food security support) coexisting with food sovereignty and community divestment issues (Healthy Alameda County 2019). Linking climate change with green career pathways in food and agriculture was a more effective educational strategy in Oakland classrooms to capture student interest.

While climate change education will manifest differently in different cities and schools across the U.S., there is no need to 'reinvent the wheel' in each city and school district. Several key points can guide future research and contribute to action-research on climate education:

1. Students will retain information best if they engage actively in hands-on projects related to climate change content accompanied by reflection activities. Solutions-oriented activities including (but not limited to) those in a school garden or other school infrastructure project are best suited to improving climate literacy for the largest number of students.
2. The school garden context is a proxy for numerous agricultural learning contexts where experiential food and climate change education can take place. Using other settings such as local farms, forestlands, conservation areas, hydroponics operations, etc. could serve a similar purpose.
3. Personal (and family) narratives, lived experiences and positive frames for food-related climate change information are important to youth first learning about a subject that is complex and potentially depressing; care must be taken to avoid presenting climate-friendly food solutions that are exclusively more expensive, time-consuming, or inaccessible to low income youth.
4. Co-teaching is a useful form of climate education professional development because it harnesses complementary expertise from teachers and researchers in order to benefit students. Partnerships between climate researchers in academia and K-12 teachers should be scaled up.
5. Appropriate assessment methods linked with experiential learning objectives must be developed for climate and energy literacy curricula, moving beyond a simplistic multiple choice post-test to include more qualitative and descriptive methods.
6. Garnering national partnerships and involvement from groups such as the National Farm to School network would aid in promoting opportunities to connect food and climate education and disseminating curricular resources more rapidly.

To truly understand the utility of this and other CCE interventions, it bears keeping in mind that it matters less whether students have memorized the ambient CO_2 concentration and more whether they are motivated to gather more information on climate change independently, have some context within which to critically interpret future information on climate, and are motivated to take up more climate-friendly actions. This can be difficult to measure, but obligates all CCE researchers to do their homework and listen to student voices directly, as advocated by Arnim Wiek in his work on evaluating transformative sustainability learning initiatives (see Wiek et al. 2014; Luederitz et al. 2017).

An innovative evaluation opportunity presents itself through paying attention to the youth-led climate strike movement[20]: through tracking student participation, motivation, and demands voiced in these initiatives, student climate literacy can be "tracked" as an evolution from open-ended calls to action towards concrete action steps demanded of elected officials and publicly accountable institutions. It is perhaps ironic that students are leading their own climate education in some of these youth-led initiatives, opening up a possibility for teachers to learn from students what they are most interested in learning about climate change, and leading to horizontal learning pedagogy directly in line with Paulo Freire's theorization of critical pedagogy.

4.8 Conclusion

Experiential food and climate change education is an emerging branch of CCE with great potential, where the school garden provides one context for experiential climate learning while many others are possible (educational farms, emerging indoor and vertical farming centers, etc). By emphasizing and teaching local forms of food production and consumption, this CCE example seeks to localize climate stewardship and in doing so reduce the carbon footprint of food system products and processes. The food-climate nexus diagram presented in Chapter 1 offers both an impetus for scaling this form of integrated food-climate education, and an example of how to do so while visualizing food-climate interactions.

This chapter reports on initial positive results from integrating CCE into both the humanities and school garden classrooms. In the case of humanities-focused CCE, students not only demonstrated gains in climate literacy, but also improved their reading comprehension. Sixth grade students performed at a level equivalent to their eighth-grade peers in terms of listing numerous climate mitigation strategies, and reported both looking up new information and speaking with friends/family about climate change more frequently than all other middle school grades. The examples from school garden classrooms more explicitly adopt and test the hypothesis that experiential CCE is more effective than didactic or lecture-based climate instruction. Results show improvements in student learning and strong student interest in the topic. However, further evaluation methodology development is needed to best capture the impacts on student action and behavior. In order to understand the efficacy of experiential CCE relative to CCE that is not experiential, a controlled experiment would be required that uses the same evaluation methodology for students with and without experiential CCE. This methodology would ideally comprise and observational element where teachers report on student "climate actions" over the course of a defined time period. In future studies, a list of core "climate actions" could be developed as a baseline for evaluators to assess whether students are carrying out these activities (i.e. participating in climate strikes, walking or biking to school, eating a

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[20] Fridays for Future (https://www.fridaysforfuture.org/), launched by Greta Thunberg's weekly school strikes, and Teach the Future (https://www.teachthefuture.uk/), a UK-led student initiative demanding that schools not only teach students more about climate change, but convert to net-zero buildings, are two examples of student-led climate action movements that are reaching international audiences.

plant-based diet, planting trees/gardens, advocating for community renewable energy installations, etc).

Both food-focused and humanities-focused CCE point at an underlying characteristic of CCE. Rather than being treated as its own subject, or topic to be covered in science classrooms, climate change is an overarching frame that infuses all sorts of school activities, processes, and classrooms, from the transportation that bring students to school, to the food that is served in the cafeteria, to the content students are covering with their mathematics, physics, government, or garden teachers. The sooner schools, farms, gardens, and other centers for education embrace climate change as a unifying theme cutting across and informing their operations, the easier CCE will be to implement and scale. Schools and youth represent an underutilized resource in the climate and food behavior change initiative. Starting in school gardens, students today can be educated and prepared to lead the radical and climate-beneficial food system transition of tomorrow.

Chapter 5: Conclusion

"A vision for a healthy, sustainable food system will only succeed if it joins with visions held by other groups beyond food system activists: people of color, Indigenous, labor, women, climate change activists. The food system touches everyone, so it can be a great organizing core as long as people are willing to work together and make compromises. The compromises must not be ones that lead to exploitation of any group or increased suffering, however; a vision must be big enough that everyone can see how their life would be better within it." ~Molly Anderson, Professor of Food Studies at Middlebury College (2019)

5.1 Building a "Big Tent"

Stepping back and looking at on-the-ground realities across the contexts of study presented in this dissertation, there are numerous examples of individuals and organizations who are theoretically on the same "team" when it comes to goals of mitigating climate change and advancing social equity, and yet engage in intense debate in their activities, rhetoric, and interactions around how to achieve these goals. Vegetarians calling out those who eat grass fed beef on Lopez for contributing to negative climate impacts; urban farmers with different visions and theories of social change choosing not to work together to advocate for policy change; educators who promote a more factual teaching of climate science arguing with those who aspire to a more holistic, socially grounded form of climate education. This antagonism among those working towards shared goals can be seen playing out on a global scale as well: environmental movements that do not adequately incorporate environmental justice, indigenous land ethics, and communities of color; climate activists who disagree about how best to reduce emissions, who bears primary responsibility for action, or whether to directly confront entrenched institutions and power structures; new farmers who glorify small-scale agriculture without acknowledging that pathways to farm ownership are not equitably available to all groups; food systems researchers who demand immediate revolution pitting themselves against those who argue for a more gradual approach to change from within the system.

Recognizing these rifts as well as the reality that the global food and climate system is currently at a critical juncture, Anderson (2019) articulates a vision for a "healthy, sustainable food system" that **joins with other visions**, key to any successful social movement. Confronting the dominant food system and greenhouse gas emitting global economy can only happen through a broad-based social movement where the majority of people across race and class lines can see themselves held in a common vision. Social movements, according to Saru Jayaraman (Director of the Food Labor Research Center at U.C. Berkeley), by definition contend directly with the centers of power; they do not avoid direct confrontation in seeking to change the status quo. Remembering as Obama repeatedly told Americans that "there is more that unites us than divides us," there is work to be done reconciling disagreement among food and climate researchers, practitioners, and activists in order to confront the forces of the status quo: corporations, bureaucracy, and fossil fuel interests that prevent progress on issues where there is wide public support, in effect subverting democracy.

For example, there is an opportunity for alignment among those who choose not to eat meat for environmental reasons and those who choose to eat grass fed meat in opposition to a common enemy: concentrated animal feeding operations (CAFOs). CAFOs contribute dramatic negative impacts to the environment and human health, beyond the footprint of their feedlots and extending to the vast acreages used to grow synthetically fertilized, monocropped grains for animal consumption. Imagine if much of this acreage was converted to growing diverse requirements of a plant-based diet for humans, and some was allocated to grass fed meat operations (the lands uses most suited to such operations, i.e. grasslands that benefit ecologically from ruminant activity). Cows contribute to pasture restoration and can lead to net carbon sequestration through aerating and adding manure to grassland soils. Furthermore, the manure from some grass fed beef operations contributes to creating high quality compost that enables organic vegetable production. There is a possible convergence between disparate food systems activism that requires further research and participatory collaborations among food scholars, consumer groups, farmers, and ranchers. Education systems can contribute to reconciling some food systems debates as well: well-crafted food and climate curricula can enable collective action by uncovering shared motivation among different actors, organizations, and individuals.

5.2 Cases in Conversation: Back to the Theoretical Frameworks

The chapters of this dissertation articulate the role of small farms and farm-based education in providing social-ecological and educational benefits to communities. Small farms are involved in educating youth, beginning farmers, and the general public about the food system as a whole, and its potential to transform into a climate-beneficial system that promotes rather than destroys human health. Many small farmers are on the front lines of pioneering climate friendly growing practices, gathering data on these practices, and educating their communities about why they are doing what they're doing. These small farmers are leading farmer-to-farmer workshops, hosting tours of their farm for the public, partnering with researchers and applying for soil health grants, and engaging with schools in their communities to provide both farm-based education and nutritious local food for school lunches. How can the work of small farmers be supported and scaled up? They are undoubtedly positive community influences and providers of essential services (healthy local food). But when so much is stacked against them in terms of marketing channels, research and technical support, land access, and political influence, how does small-scale farming come to be an occupation that more people are drawn to, and one that is economically viable? According to a recent publication (DeLonge et al. 2016), less than 1% of the USDA Research, Education and Extension (REE) budget is allocated to support agroecological and organic farming operations (see Figure 23). In the policy realm, change is needed in budget allocations, incentive structures, and subsidies in order to truly scale the food system transition work that small farmers are leading (Brescia 2017). Looking to the technology and infrastructure arena, farmers in the cases presented clearly state that additional tools, equipment and facilities appropriate for processing and transporting smaller quantities of food items over shorter distances are also integral to allowing food systems to relocalize.

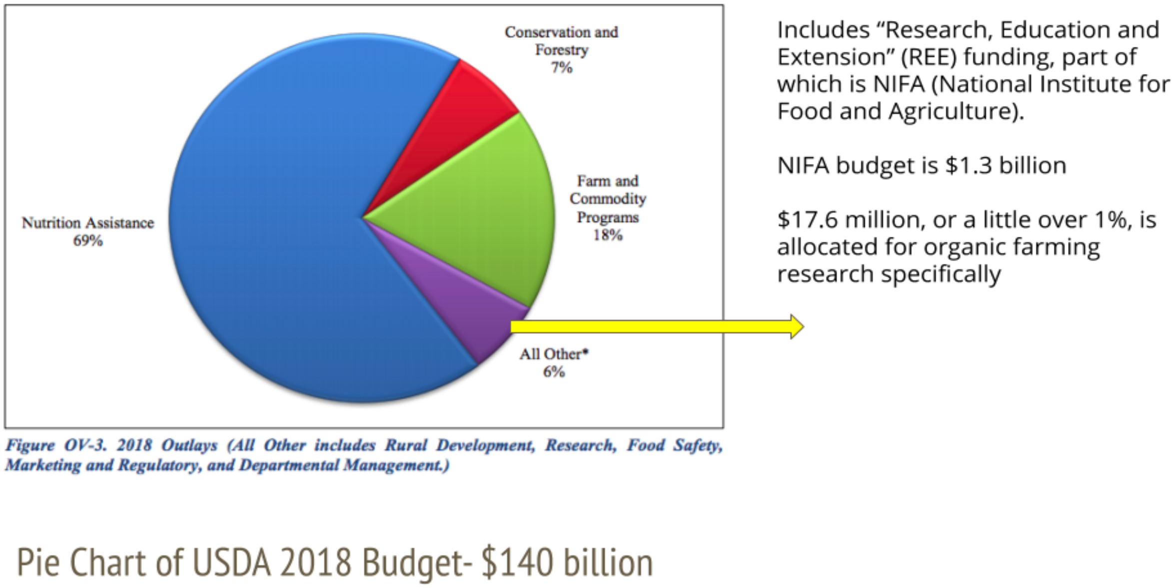

Figure 23- USDA 2018 Budget

Small farmers in developing countries are producing 70% of the world's food supply on 30% of the available agricultural land (Wise 2019), but some regions of the world are inherently more difficult places to produce food than others, and some degree of large scale farming and global distribution will be necessary to support a growing global population and buffer against adverse conditions in particular locations. Distribution channels must shift in order to allow food to more easily reach the people and places most in need, and export-oriented economies must refocus on feeding their own people—these are areas for future research and civic engagement.

This dissertation is not arguing that all farms must be small farms, nor is it a prescription for how or what food should be grown in each region of the world. It is also not arguing that small agroecological farms are "the future of food;" many competing visions exist for how food should be produced in the future, from controlled-environment agriculture to lab-grown meat to renewed attention to soil health. My cases do not speak to every part of the world, but rather are nested within and illustrative of larger theoretical frameworks. I am not arguing for the complete abandonment of a global food system to be replaced with entirely small organic farms serving local communities all over the world. Rather, I am arguing for the valuable social, ecological, and educational role small farmers are playing in addition to producing food—a role that current industrial production farms are not able to play—and arguing for political-economic system shifts that allow small farms to co-exist with larger farms and "scale across" as a vital form of human connection to the food system. This role would potentially be lost with the disappearance of small farmers.

This dissertation adds to the available data on the benefits and strengths of allowing food systems to relocalize in certain contexts where this is desirable or under way. Some see an inherent benefit in local choice and sovereignty over resource production and consumption, whether that resource is energy (see Avila 2018), food (see Sowerwine et al. 2019), or forest (Barsouk 2018). A bio-regionally appropriate approach to food production is analogous to bio-regionally appropriate energy generation in that both recognize the value of doing what makes sense in a particular place. Where it is warm, grow heat-loving plants: where it is windy, install wind turbines. Drawing on Amory Lovins' "soft path" approach for the American energy sector, a soft path for food systems would entail regionally tailored production systems matched with appropriate technology for processing and distributing food products from areas where there is plenty to areas where food is scarce, starting from within the region. This bears similarities to distributed energy resource (DER) planning that incorporates batteries alongside generation technologies to store energy when it is plentiful and provide energy in times when demand is high.

In arguing for relocalization of the food system and for reconnecting people to their food sources, this dissertation offers an indirect critique of the "feed the world" narrative prevalent in much food systems research. Many food related research articles, including materials promulgated by the U.N. Food and Agriculture Organization (FAO), begin with a statement such as, "in order to feed a population of 9 billion by 2050, the world must double its current rate of food production, even as climate change threatens our ability to produce food at current rates." Statements such as this overtly ignore the reality that the world is currently producing more than enough calories to support the global population, yet some people have too much and others do not have enough to eat, and up to 40% of food that is produced in developed countries such as the United States is ultimately wasted (NRDC 2017). The global food system is producing a glut of grain and commodity crops often used for animal feed or for biofuels in some cases, focusing on profits rather than feeding the hungry[21]. In the United States, almost 90% of total cropland acreage (~250 million acres) is planted with just three crops: corn, soybeans, and wheat (in order of greatest total acreage), much of which is used for non-human consumption (e.g. corn for ethanol and animal feed; USDA ERS 2019). There is a food distribution problem in the U.S. and globally, in addition to a food production problem (related to quality and diversity of food produced, not quantity), rooted in systems of inequality and legacies of racial and economic discrimination. However, this dissertation does not directly engage with this debate, as it does not conduct the national or global modeling of land use requirements for agroecological production systems and does not attempt to average or quantify amounts of food produced per acre from such systems.

Reconnecting people to the simple yet powerful act of growing food, the production element of the food system, has the potential to unlock advocacy for change in other system elements (e.g. distribution, waste recycling). Those who produce food or have knowledge about farming/food production are more likely to seek out shorter food supply chains and local distribution points, as well as less likely to waste food, knowing the time and energy that went into growing it in the first place. Reconnecting people with food production and thus, the food system as a whole, is part of the essential social-ecological and educational value that small farms provide to community.

Recalling the work of Ostrom and SES scholars, it is clear that the policy work required to govern a return to a food production "commons" in some local arenas will be contentious, and will need to overcome controversies and tensions among different food system stakeholders. Some changes to local food systems may create winners and losers, favoring farmers over low income consumers, or farm owners over land lessees. It is the role of food systems-informed policymakers as well as ordinary citizens to consider trade-offs and synergies, and seek to make the best possible decisions for their local, regional, or state contexts, while continuing to pay attention to and advocate for appropriate national shifts in funding, subsidies, etc. (through

[21] As Dr. Timothy Wise states, "hunger isn't caused by a scarcity of food. Hunger is caused by a scarcity of power on the part of food producers and the poor. Power over land, water, and other food-producing natural resources. And the power to earn incomes that can allow people to buy the food they need" (Wise 2019).

changes to the Farm Bill and Federal Crop Insurance dynamics in the U.S.). The work will not be easy and will benefit from further research exploring effective as well as ineffective policies geared towards facilitating sustainable local food system governance.

5.3 Future Questions and Next Steps

While my dissertation does not address explicit strategies for greening and improving the sustainability of the industrial food system, research in this direction is urgently needed. It is not realistic to expect the dominant food system paradigm to disappear overnight, replaced by small scale agroecological farms. Therefore, efforts to increase water use efficiency, reduce runoff laden with nitrogen fertilizers and chemicals, reduce fertilizer, pesticide, and herbicide application rates, reduce nitrous oxide and methane emissions, and increase biodiversity on large industrial farms are important areas for research and extension. Examples abound in the work of Don Cameron at Terra Nova Ranch, pioneering the practice of on-farm water recharge by flooding his fields in winter to recharge depleted groundwater aquifers; David Doll working in the capacity of Farm Advisor in Merced County to promote practices such as Whole Orchard recycling to convert orchard biomass into a valuable soil building resource; and Gabe Brown of Brown's Ranch in North Dakota, reducing the use of herbicides and pesticides as he converts hundreds of acres to no-till farming and allows a healthy community of diverse soil microorganisms to control weeds and pests. Key practices such as no-till farming, optimal use of biomass (considering opportunities for composting, biochar production, mulching, and energy production), groundwater recharge, and substitution of chemical inputs for natural processes require further place-based research in order to develop and disseminate "best practices" for large scale operations through farmer-to-farmer and extension networks.

Future food systems research endeavors would benefit from integrating social scientists into interdisciplinary research teams and integrating research with local policymakers and policy processes as early as possible. Many expressed needs from farmers on both Lopez and in the East Bay cannot be addressed by scientific research, but call for policy change or intervention. Some policies will be harder to enact than others, for example, those calling for the restructuring of hegemonic private property systems in favor of cooperative and public ownership models. Policy recommendations for scaling climate friendly local food systems arising from each chapter include:

- From the Lopez case, engage in county level agricultural planning to better support farmland transition and opportunities for new farmers (including affordable housing, opportunities for cooperative farming, aggregated distribution systems or inter-island food hub, and small-scale farming infrastructure); protect farmland from encroaching second home real estate market and further develop public and cooperative land ownership models; fund regenerative agriculture practices to increase adoption[22]
- From the East Bay agroecosystem, designate and protect urban farms as planned spaces in cities safeguarded from development pressures; provide public land resources and public informational support to urban farmers

[22] See Electris et al. 2019 for report on financing strategies for regenerative agriculture ("Soil Wealth: Investing in Regenerative Agriculture Across Asset Classes")

- From the climate education chapter, enable effective climate change education for all students in all schools, through investigating available curriculum resources and providing funds for teachers to receive professional development in CCE; continue to integrate experiential food systems and climate on farms.

Inspired by Dr. Timothy Wise's book *Eating Tomorrow: Agribusiness, Family Farmers, and the Battle for the Future of Food* and Dr. Molly Anderson's recent paper "The importance of vision in food system transformation," I aim to contribute to building and implementing a shared vision for tomorrow's food system, one that is climate mitigating, ecologically restorative, land-based, and empowering of small farmers and historically marginalized groups in food system politics. A vision "is a beginning for transformation, but it requires policy that enables it to be enacted, ideally through democratic processes. The vision, buttressed by policy and democratic governance, is what determines where people are able to buy food, how much they pay, whether farmers earn decent incomes, and whether the food is healthy" (Anderson 2019). Lopez Island food system actors have made incremental progress articulating a vision since 1989, starting with the mission statement of the Lopez Community Land Trust. The East Bay region of the San Francisco Bay Area is building a vision for increasing food security via urban agriculture through the work of Food Policy Councils in Berkeley, Richmond, and Oakland. Small farms in both Washington and California are starting to put forth a vision for how regenerative agriculture and farm-based education can aid in the battle against climate change. Bringing these visions together under the polycentric governance model, policy recommendations must be targeted at the appropriate level: county governance for zoning code updates and land use designations, state governance for climate and environmental education standards and funding, and national level policy to revamp the Farm Bill into an incentive package for smaller-scale, regenerative, relocalized agricultural operations.

Building off of the body of research presented in this dissertation, one of my future goals is to establish a Climate Farm School, where young people can come to a demonstration farm and deepen their understanding of the climate crisis while engaging in climate solutions through producing food. The purpose would be threefold: 1) establish a demonstration farm that models climate friendly agricultural practices while producing and distributing food, 2) educate young people and aspiring farmers how to implement and improve climate friendly practices, and 3) engage with local universities in research projects to explore and scale agricultural climate change mitigation/adaptation. My vision is that this farm school could arise through partnership with an existing farm, or through the right opportunity of land acquisition and fundraising. Further information can be found at https://www.laneysiegner.com/climate-farm-school. While I seek to engage first with the youth education sector, I can imagine a parallel "Climate Farm School" for policymakers to better understand and connect with climate-friendly farming operations in their areas of jurisdiction to inform and direct their policy proposals. Bringing young people and policymakers into the sustainable food system transition process is a critical step for food system researchers to take in order to realize positive change.

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APPENDIX

KEY TERMS AND ACRONYMS

Commonly Used Acronyms

1. CCE- Climate Change Education
2. FAO- U.N. Food and Agriculture Organization
3. GMO- Genetically Modified Organism
4. RA- Regenerative Agriculture
5. SES- Social-ecological systems
6. UA- Urban Agriculture
7. UAE- Urban Agroecology

Key Terms

1. Agroecology- defined as "the application of ecological principles to the study, design and management of agroecosystems that are both productive and natural resource conserving, culturally sensitive, socially just and economically viable" (Altieri and Toledo 2011; Gliessman 2012; quoted in Tornaghi 2016 and DeLonge et al. 2016). Agroecology in its

most expansive form coalesces the social, ecological, and political elements of growing food in a manner that challenges the dominant industrial food system paradigm, and explicitly seeks to "transform food and agriculture systems, addressing the root causes of problems in an integrated way and providing holistic and long-term solutions" (FAO 2018). It is simultaneously a "a practice, a science, and a social movement" (Wezel et al. 2009), to which this dissertation adds "a method of inquiry."

2. Chemical/industrial food system- food system based on what Vandana Shiva calls the "dominant paradigm" and the "Law of Exploitation, which sees the world as a machine and nature as dead matter" (Shiva 2016). Relies on the intensive application of chemical-based Nitrogen fertilizers, pesticides, herbicides and heavy machinery to cultivate extensive monocropped fields. Linked to current farm subsidy structure and National Farm Bill policies that incentivize chemical applications in order to receive federal crop insurance.
3. Climate literacy- "demonstrating an understanding of the essential principles of Earth's climate system, knowing how to assess scientifically credible information about climate, communicating about climate change in a meaningful way, and being able to make informed and responsible decisions with regard to actions that may affect climate" (U.S. Global Change Research Program 2009)
4. Cooperative farming/agriculture- comprises a variety of ownership and leadership structures where land and/or business ownership is shared among a group of individuals. Cooperatives can either be hierarchical, with one primary leader, or horizontal, with equal decision-making stakeholders, and can be large or small. As opposed to investor-owned or privately owned farms, cooperative farms imply a group of decision-makers and partners working together towards a common agricultural project or operation.
5. Environmental literacy- the ability, both individually and together with others, to make informed decisions concerning the environment; willingness to act on these decisions to improve the well being of other individuals, societies, and the global environment; and participation in civic life (paraphrased from NAAEE 2011)

6. Food literacy- understanding the impact of your food choices on your health, the environment and our economy (Food Literacy Center); "entails understanding the systems through which food progresses from soil to table and back to soil: how food is grown, processed, transported, acquired, prepared, and consumed, and how waste is managed. It includes recognizing the impacts on individuals, communities, and the natural world of our food-related decisions and actions. It nurtures appreciation of the intricate webs of relationships that bind all of life and link food, culture, health, and the environment. Food literacy promotes the knowledge, values, and skills that enable effective action on behalf of healthy people and resilient communities in harmony with nature." (Zenobia Barlow, Center for Ecoliteracy
7. Food System- "The **food system** encompasses all the activities and actors in the production, transport, manufacturing, retailing, consumption, and waste of food, and their

impacts on nutrition, health and well-being, and the environment" (IPCC Land Use report, 2019)

8. Polycentric governance- Polycentricity refers to a governance system with multiple governing authorities at differing scales. Governance is defined as the exercise of deliberation and decision making among groups of people who have various sources of authority to act and may be practiced through a variety of organizational forms (e.g., bureaucratic department, watershed council, nonprofit organization). In polycentric systems, each governance unit has independence within a specified geographic area and domain of authority, and each unit may link with others horizontally on common issues and be nested within broader governance units vertically. (Biggs et al. 2012).
9. Regenerative agriculture (RA)- "a system of farming principles and practices that increases biodiversity, enriches soils, improves watersheds, and enhances ecosystem services. By capturing carbon in soil and aboveground biomass, Regenerative Agriculture aims to reverse global climate change. At the same time, it offers increased yields, resilience to climate instability, and higher health and vitality for farming communities." (Terra Genesis International 2016). Regenerative agriculture is a term most aptly applied to describe production practices that seek to build soil carbon through maximizing plant diversity, minimizing soil disturbance, and keeping the soil covered. It does not share the same revolutionary political-economic implications as agroecology, and it is feared by some that RA has been co-opted by big food corporations seeking to consolidate their own power while being seen as aligning with climate solutions.
10. Sustainable food systems- Jules Pretty associates five forms of "capital" that must be considered when categorizing a food system as sustainable: natural, physical, social, financial, and human capital (Pretty 2008). Gliessman's taxonomy of socio-ecologically sustainable food systems specifies 5 levels that support this end result (Gliessman 2014):
    - Level 1: improving systems efficiency to reduce use of external inputs
    - Level 2: Substituting more sustainable inputs and practices into farming systems
    - Level 3: Redesigning systems based on ecological principles (agroecology)
    - Level 4: Re-establishing connections between producers and consumers to support a socio-ecological transformation of the food system
    - Level 5: Establishment of an equitable, participatory, and just food system that is built upon the farm-scale practices of L3 and the food relationships supported by L4
11. Urban agroecology (UAE)- UAE has emerged as a concept that extends the definition of "agriculture" to include the social-ecological and political dimensions as well as the science of ecologically sustainable food production in cities (Altieri & Nichols, 2019; Tornaghi, 2016; Dehaene et al., 2016).

Variables for Self-Organizing SES in Lopez Context

Variables for Self-organizing SES in Lopez context

Ostrom's Variable	Description	Application to Lopez Context
Size of resource system	Very large territories are unlikely to be self-organized given the high costs of defining boundaries, monitoring use patterns, and gaining ecological knowledge. Moderate	Approximately 5,000 acres of farmland

	territorial size is most conducive to self-organization	
Productivity of system	Users need to observe some scarcity before the invest in self-organization	LCLT sponsored a study in 2015 titled "Can Lopez feed itself?" that estimated 10% of local food consumption is currently supplied by local farms, a number that farmers aspire to grow; however, productive farmland is threatened by development
Predictability of system dynamics	System dynamics need to be sufficiently predictable that users can estimate what would happen if they were to establish particular harvesting rules	Lopez system dynamics are predictable
Resource unit mobility	Self-organization is less likely with mobile resource units (e.g. wildlife, water) than with stationary units (trees, plants)	The Lopez resource units are stationary, so easier to self-organize around
Number of users	Typically larger groups are harder to self-organize, but effect on self-organization depends on other SES variables and types of management tasks	27 farms are listed on the LCLT "Local Food Products Guide," representing approximately 50 individuals
Leadership/entrepreneurship	Some users have entrepreneurial skills and are respected local leaders as a result of prior organization for other purposes	Several notable leaders with entrepreneurial skills are present in the Lopez farming community
Collective-choice rules	When users have full autonomy to craft and enforce some of their own rules, they face lower transaction costs	Farms can craft and enforce some of their own rules, within county regulatory boundaries, but there is little direct evidence of this to date
Knowledge of SES/mental models	When users share common knowledge of relevant SES, how their actions affect each other, and rules from other SES, self-org. is more likely	Lopez farmers are familiar with principles of self-organizing; many are college-educated and have some knowledge of SES and other organizational models
Norms/social capital	Users share moral and ethical standards regarding how to behave in group, and thus norms of reciprocity; have trust in one another to keep agreements	High degree of shared moral/ethical standards, reciprocity and trust among Lopez farmers
Importance of resource	In successful SES, users are either highly dependent on the resource for their livelihoods or attach high value to the sustainability of the resource	Very high importance placed on local food resource

UN FAO 10 Elements of Agroecology

UN FAO 10 Elements of Agroecology

Element of Agroecology	Brief Description

1) Diversity	Diversity at multiple scales including genetic diversity, species diversity, agroforestry practices, crop rotation, and crop-livestock systems that in turn lead to market diversity, resilience, nutritional diversity, and improved health outcomes
2) Synergies	At field scale, use diversified crop-livestock or aquatic systems to enhance ecological function and resource-use efficiency; at landscape level, strategize productive activities in space and time to boost ecosystem services
3) Efficiency	Relates to natural resource use especially those that are abundant /free (solar radiation, atmospheric C and N); enhance biological processes to require fewer external inputs
4) Resilience	Greater capacity to recover from disturbances
5) Recycling	Rejects waste as a human concept not part of natural ecosystems; closes the loop at both farm and landscape scales
6) Co-creation and sharing of knowledge	Non-hegemonic forms of information exchange via horizontal learning platforms, i.e. farmer to farmer context-specific knowledge transfers; blends traditional and indigenous knowledge with global scientific knowledge
7) Human and social values	Emphasis on dignity, equity, inclusion and justice; creates opportunities for women; recognition that improving ag. livelihoods is essential for sustainable food systems
8) Culture and food traditions	Re-balances tradition and modern food habits to promote healthy food production and consumption; values cultural varieties and crops
9) Responsible governance	Transparent, accountable and inclusive mechanisms to create enabling environment supporting producers to transform their systems; i.e. school feeding and public procurement programs, subsidies for ecosystem services
10) Circular and solidarity economy	Reconnecting producers and consumers of food; creating space for alternative, innovative, and non-market forms of exchange

Learning Objective/Lesson #	Topic	Experiential Activity
1. What is climate change? How do food systems interact with climate systems?	Weather vs. climate	Climate storytelling exercise, weather data-logging in garden
2. What factors, including agriculture, have caused the rise in global temperatures?	Causes of climate change; Carbon cycle	CO_2 Freeze Tag
3. What are the effects of climate change and what will that look like here?	Effects of climate change	National Climate Assessment scavenger hunt
4. How can we monitor effects locally?	Farmer monitoring efforts	Walking tour of school garden or local farm, soil water holding tests
5. What are local solutions to climate change?	Climate action and solutions	Composting
6. Launch class food-climate action project(s)	Student determined, i.e. biochar	School garden improvement project/Climate Resilience plan